THE ENGINEER.

Blowers and Compressors.

The Development of Blowers and Compressors.

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THE evolution of the art of engineering is a slow and laborious process, in which progress is accelerated, on the one hand, by industrial and other demands and often retarded, on the other hand, by unexpected difficulties in manufacture and operation. Those who labour to overcome or circumvent the practical difficulties rarely leave us a record of their experiences, and this conspicuous absence of case histories in engineering makes it difficult to prepare even a short history of the development of any one branch of the art, especially if that branch is one of the less spectacular. In the following notes an attempt is made to deal with the historical and technical developments of certain well-defined branches of blower and compressor engineering.

Blast-furnace Blowers.

The earliest blast-furnace blowers of any importance were large slow-speed blowers driven by beam engines. The blowing cylinders were vertical and both the suction and delivery valves were usually large leather flap valves seating on vertical, or nearly vertical, gridiron seats. The valves were stiffened with light iron frames. Such engines occupied a very large amount of space. The writer had the happy experience, nearly thirty years ago, of taking indicator diagrams from the steam cylinder of one of these engines built in the 'fifties. The piston stroke was 11ft. and the speed of rotation only 13 r.p.m. The indicator cord attached to the drum of the lower indicator stretched upwards and disappeared through a hole in the grating around the cylinder top. It was attached to a convenient point on the Watt parallel motion.

In order to employ higher piston speeds positively controlled valves were introduced by Slate in 1850. Slate first used an ordinary slide valve and was enabled thereby to increase piston speeds to 600ft. per minute. Daniel Adamson, in 1859, introduced piston valves for large blowing engines. One of the most successful valves was the Southwark, introduced in 1888 by the American firm, the Southwark Foundry and Machine Company. It was a slide valve shaped like a gridiron, moving on faces machined on the top and bottom covers of the cylinder. It gave a large opening with a short travel. By its use the clearance volume could be reduced to an absolute minimum. Positively operated valves proved to have undoubted advantages over the older automatic valves, but they added complications to a very simple machine and to the cost of upkeep. Meanwhile, improvements in materials and manufacturing technique resulted in the evolution of entirely satisfactory automatic valves. Light plate valves were introduced early in the present century and soon proved satisfactory. They were used for both inlet and outlet and arranged as multiple valves.

The unwieldy beam engines were later replaced by the "steeple" engine, which could be built either as a simple or compound engine having the steam and blowing cylinders in tandem, the former usually being above the latter. In the early part of the present century the so-called "quarter-crank" engine was introduced, consisting of two vertically independent engines, one a high-pressure engine driving a blower from its crankshaft, and the other a low-pressure engine taking steam from the high-pressure engine and driving a second blower from its crankshaft. Both the steam and air cylinders are more accessible than in the steeple engine, but the quarter-crank engine occupied a good deal of room.

About the year 1895 the large blast-furnace gas engine was first applied to the driving of blast-furnace blowers. The development of this type took place chiefly in Germany and Belgium. The arrangement finally adopted comprised a horizontal tandem engine with two double-acting gas cylinders and a blowing cylinder at the end remote from the fly-wheel. The overall length of such an engine was considerable and in some cases a horizontal tandem gas engine was used, but the blowing cylinder was arranged on columns directly above the crank. Elaborate gas cleaning plant had to be employed to reduce the dust content of the gas to about 0·0003–0·001 gramme per cubic foot. Although the gas-driven blower had undoubtedly a high overall thermal efficiency, the cost of maintenance and the consumption of lubricating oil were both high.

The use of the turbo-blower dates back to the year 1902. In that year the first centrifugal blower was made to the designs of the late Professor Rateau. In the same year the first blast-furnace blower constructed to the designs of the late Sir Charles Parsons was delivered from the Heaton Works. This was, however, an axial flow machine. Its rotor carried several rows of reversed reaction blading, while the cylinder was fitted with an equal number of rings of fairly wide blades, which restored the absolute velocity of the air to a more or less axial direction. A large number of stages is necessary with the axial flow construction. For instance, a blower delivered by the Parsons Company in 1904 and designed to supply 3000 cubic feet per minute at 8–15 lb. per square inch gauge had no less than fifty-two pairs of blades. In 1909 the first centrifugal compressor left the Heaton Works.

The turbo-blower is very well adapted for blast-furnace work. When a steam turbine drive is adopted and the steam is supplied by gas-fired boilers at a moderately high steam pressure the overall heat consumption per air horse-power (adiabatic compression basis) is very little more than that of the gas engine-driven reciprocating blower. The space occupied by the turbo-blower is comparatively small. It may be constructed to handle very large volumes of air per unit. For example, the blowers built by Brown, Boveri and Co. for the large blast-furnaces at Magnitogorsk in the U.S.S.R. are capable of delivering 93,000 cubic feet of free air per minute at 22·8 lb. per square inch gauge. In the ideal arrangement of blast mains, *i.e.*, when each blower serves its own furnace, the turbo-blower can be provided with control gear which automatically varies the speed of the driving turbine in such a way that the blower delivers a constant volume of air to the furnace, irrespective of the resistance of the furnace charge. Control gear designed by the British Thomson-Houston Company, Ltd., for blast-furnace blowers is fitted with correctors for air temperature, barometric height, and atmospheric humidity, so that the blower actually supplies a constant weight of oxygen.

In iron and steel works where air may be required for the blast-furnace at, say, 12 lb. per square inch, and at, say, 30 lb. per square inch for the Bessemer converters, the series-parallel turbo-blower has been used with success. It comprises a blower with perhaps eight stages, which, when operating in series will raise a certain volume of air per minute to the pressure of 30 lb. per square inch. By means of suitable air belts and change-over valves, the last four stages may be arranged to operate in parallel with the first four. In this case the blower operates as a double-flow machine, and will deliver a larger volume of air at the lower pressure.

Positive Rotary Blowers and Compressors.

For the smaller outputs and moderate pressures positive blowers have long been used with considerable success. One of the best known is the Roots blower, which has been used extensively for supplying air to smithy fires, cupolas, Bessemer converters and the like. In recent years this type of blower, improved by more accurate methods of manufacture, has been applied for scavenging and supercharging marine oil engines.

The well-known cell or crescent type of blower is suitable for volumes varying between 50 and 2500 cubic feet per minute. Single-stage blowers of this kind are available for pressures of 20 lb. per square inch when uncooled and 30 lb. per square inch when cooled. Crescent type compressors of relatively small output arranged as two-stage machines have been constructed abroad for pressures of 230 lb. per square inch with quite a good efficiency and economy of space.

Reciprocating Air Compressors.

Compressed air forms a safe and convenient medium for the transmission of power and its use for this purpose was suggested by Denis Papin in 1695. Its successful application had to await the developments in methods of manufacture and construction which took place during the early part of last century. One of the earliest applications in this country was the installation in 1850 of a compressed air haulage engine in Govan Colliery. A description of the compressor will be found in the "Proceedings" of the Institution of Mechanical Engineers for 1856, and is well worth reading. The compressor consisted of two cylinders operated by a beam engine, and each cylinder was virtually a single-acting air pump with three sets of valves, each set comprising forty-four brass balls, 2in. diameter. Owing to the "high" pressure of the air, amounting to 20 lb. to 30 lb. per square inch, provision was made for preventing leakage by injecting water from a tank subjected to the delivery pressure. The state of knowledge at that time regarding the compression of air may be gauged by the fact that it was expected that the temperature of the air after compression would reach the melting point of tin, namely, 442 deg. Fah., whereas, even an adiabatic compression up to 30 lb. per square inch would not produce a temperature greater than about 250 deg. Fah. Wet compression was used up to 1870, chiefly in Germany and Belgium. The cylinder was double-acting, horizontal, and had large upturned bends, more or less splayed out at the top, at each end. The suction and delivery valves were arranged at the top of these bends, as shown by the accompanying drawing, Fig. 1. The ends of the cylinder were filled with water which oscillated back and forward with the piston. Air was drawn in and compressed above the water surface. In order to maintain the water at a suitable temperature, a small amount was supplied to the compressor cylinder every stroke by a force pump, the excess water escaping with the air into a receiver from which it was drained periodically. In general, on account of the inertia of the water, the piston speeds were limited to about 150ft. per minute, but improved design later permitted the piston speed to be increased to about 300ft. per minute.

In an alternative form of wet compressor, water is sprayed into the compressor cylinder in the form of

a fine mist during the compression stroke. If some of the published figures are to be believed, a remarkably close approach to isothermal compression was achieved by the employment of wet compression. For instance, in the air compressors used in the driving of the St. Gothard Tunnel, the final air pressure was 103 lb. per square inch and the final air temperature varied from 53 deg. to 59 deg. Fah. In all probability, very cold injection water was available. In the early days of air compressors, wet compression was considered on the whole to be superior to dry compression, but after about 1885 wet compression gradually went out of vogue.

Stage compression was first suggested in 1829 by the Englishman, William Mann, but Mann did not suggest intercooling between stages. This first appears to have been suggested in 1849 by Baron von Rathen, who proposed to compress air in stages to get a pressure of 750 lb. per square inch for locomotives.

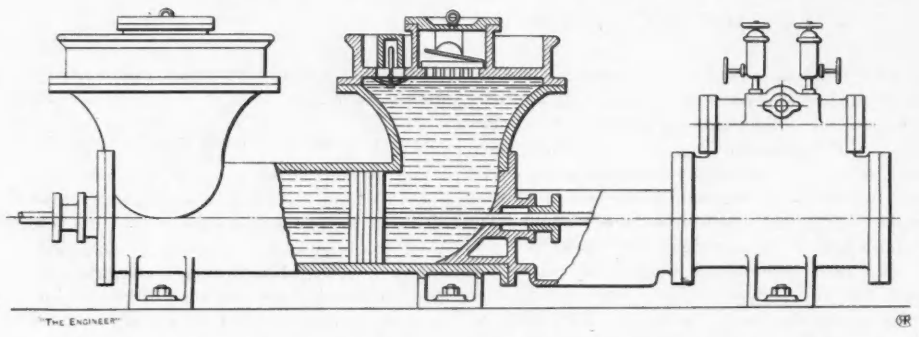


FIG. 1—ARRANGEMENT OF AIR COMPRESSOR FOR WET COMPRESSION

The torpedo, invented by the Austrian naval officer, Monsieur Luppis, and improved by Whitehead, was responsible, indirectly, for very considerable advances in high-pressure compressors. The Whitehead torpedo was introduced into this country in 1870 and was at that time propelled by an air engine working at 600 lb. per square inch. In 1877 Peter Brotherhood, Ltd., constructed steam driven compressors to compress air to 1000 lb. per square inch for torpedo work. The working pressure has steadily increased since those days. The 1905 Brotherhood compressor was capable of compressing air to 2500 lb. per square inch. The compressor was a four-stage machine having only two compressor cylinders fitted with stepped pistons. The cylinders were water-jacketed and tubular intercoolers were employed between stages. In those days leather packings were used for each of the four stages, but these soon gave place to metallic packing. Several firms nowadays construct four-stage compressors to work at 3500 lb. pressure for torpedo service.

The most vital parts of the reciprocating compressor are undoubtedly the valves. In some of the earliest constructions a flap valve was used for the suction and a heavy mushroom valve for the delivery. As design advanced positively operated suction valves were adopted in order to fill the cylinder with the least possible drop in pressure. Valves of the Corliss and Riedler type were then popular in America. The delivery valves were normally automatic. The Hoerbiger-Rogler automatic plate valve was introduced some thirty years ago and has been used with conspicuous success and little change ever since. The working part of the valve is a plate of tempered steel about $\frac{1}{16}$ in. or less in thickness, rolled and cross-rolled to ensure homogeneous material. Its great advantages are the extreme lightness relative to the area, the small lift, noiseless operation, and long life. For high-pressure stages small poppet or thimble valves are used.

TURBO-COMPRESSORS.

It is little more than thirty years since the first turbo-compressor was constructed. As already stated above, centrifugal blowers had been built since 1902 to the patents of Rateau. In 1906 Messrs. Brown, Boveri constructed one of the first, if not the first, compressor of the centrifugal type. This machine (Fig. 2) was made specially for the Société des Turbo-Moteurs à Combustion, of Paris, to operate as an auxiliary of the unsuccessful gas turbine of Armengaud and Lemale, and had three cylinders in line. It was driven by a steam turbine and designed to compress 2100 cubic feet of free air per minute to a pressure of 51 lb. per square inch gauge. The cylinders were water-jacketed.

The advantages of the centrifugal compressor were quickly recognised and several firms on the Continent, in England, and in America took up their manufacture. For the pressure of 100 lb. gauge, which is so widely used for power transmission, the three-casing design was at first common. As greater confidence was obtained by the constructors and as better alloy steels became available the peripheral speed of the impellers was steadily increased from 350 ft. to 750ft. and 800ft. per second. Other things being equal, the pressure ratio of compression per stage varies as the square of the peripheral speed and, consequently, as the peripheral speeds were increased the necessary number of stages went down. Thus the early three-casing machines soon gave place to two-casing machines and later, by 1914, German firms were building compressors for delivery pressures of 85 lb. per square inch gauge in a single cylinder. Present-day constructions allow of machines of moderate output being constructed with a single cylinder and a delivery pressure of 140 lb. per square inch gauge. The running speed of such compressors usually lies between the first and second critical speeds of the rotor.

A notable difference between reciprocating and centrifugal compressors is that, whereas in the former an important loss is that due to friction which is mostly external to the compressor cylinder and does not affect the air temperature to any appreciable extent, in the latter the principal losses are surface friction, shock losses, disc friction and leakage, all of which tend to make the increase in air temperature during compression greater than that resulting from an adiabatic compression. In consequence, effective cooling is more important with centrifugal compressors. The early compressors were jacket cooled and had intercoolers between the cylinders. Turbo-compressors without any internal cooling, but with intercoolers after every third stage of compression, were introduced about twenty years ago.

In jacket cooling the casings are arranged with hollow spaces through which water circulates. In some constructions both sides of the air passages are water-cooled. This arrangement, while advantageous from the point of view of cooling, requires rather complicated castings and demands clean cooling water; otherwise it is necessary to clean out the jackets frequently, and this is not a simple process. In the alternative construction which requires simpler castings, the air passages through the diffuser and return channels are cooled on one side only. In compressors of this type the water jackets are easily cleaned, even while the machine is in operation.

Prior to the war the German firm of C. H. Jaeger and Co. adopted a simple and ingenious form of inter-stage cooling. The return channel leading from each diffuser to the inlet of the succeeding impeller was made wider than normal and into this space, both in the upper and lower parts of the cylinder, were fitted banks of semi-circular tubes expanded into headers and arranged concentrically with the shaft. Cold water was circulated through the tubes. To judge by the published test results, such cooling was quite effective. This construction was later superseded by intercoolers with straight tubes, which are more easily cleaned. Compressor construction is somewhat simplified by the use of intercoolers and the designer has a freer hand in fixing the amount of cooling according to the requirements.

There does not appear to be any definite tendency at present to adopt one kind of cooling system to the exclusion of the other, either in England or abroad. Quite definitely, each system has its advantages and disadvantages.

REGULATING GEARS FOR TURBO-COMPRESSORS.

As is well known, there is at any given speed a certain limit of output, below which the operation of a turbo-compressor becomes unstable. This output is known as the "pumping limit" or "surging point." At an early stage in the development of the turbo-compressor various forms of regulating gear were devised with the object of preventing the compressor output falling below the surging point. In the simplest system, a blow-off valve coupled to the discharge main and situated between the compressor and the non-return valve is automatically caused to open just before the delivery volume falls to the pumping limit. As soon as this surging valve opens, the main non-return valve closes. The compressor then discharges to atmosphere, the delivery being just in excess of the pumping limit. This method is wasteful and was soon improved by fitting a throttle valve in the compressor suction, in addition to the blow-off valve placed between the compressor outlet and the main non-return valve. As the pumping limit is approached, the compressor inlet throttle is nearly closed, the non-return valve in the discharge pipe closes and the blow-off valve is opened to atmosphere. The compressor impellers are then rotating in a partial vacuum and discharging a relatively small mass of air.

Regulating gears which ensure a nearly constant delivery pressure have long been in successful use. When the compressor is steam turbine driven, this control is effected by varying the speed of the turbine; with a constant-speed electric drive a sensibly constant delivery pressure is maintained by the automatic operation of a throttle valve in the compressor suction.

TURBO-COMPRESSORS FOR MODERATELY HIGH PRESSURE.

The several advantages which the centrifugal compressor possesses over its reciprocating rival have caused engineers to consider its application to the production of moderately high pressures. At first sight, the turbo-compressor is apparently quite unfitted to play the *rôle* of high-pressure compressor. This deficiency is evident when it is considered that if air is the medium being compressed, the ratio of compression per stage is a mere 1·2, or even less. Then, again, the losses in the centrifugal compressor, due to disc friction and surface friction in the impeller and diffuser passages are likely to be increased as the pressure of the fluid is augmented. There are also lower limits to the quantity of gas which can be compressed in an economical manner, for if the terminal pressure of the gas is very high, its specific volume is so small that extremely small impellers are essential in the later stages of the compression. Fortunately, the requirements of efficiency and of output limits can be satisfied by the same change in design, namely, a reduction in the impeller diameter and an increase in rotational speed in the later stages of the machine. Thus, the early stages will have impellers of a diameter dictated chiefly by the suction volume, running at a speed which gives for that diameter a suitable peripheral speed. The later stages have impellers with a much smaller diameter, but a higher rotational speed, the latter being obtained by the use of a speed-increasing gear between the L.P. and H.P. stages. The disadvantage of a possibly increased cost is in many cases more than outweighed by the advantages of a smaller space occupied, a rotary machine, the absence of valves, economy of lubricating oil and the entire absence of internal lubrication with resulting clean gas. The future

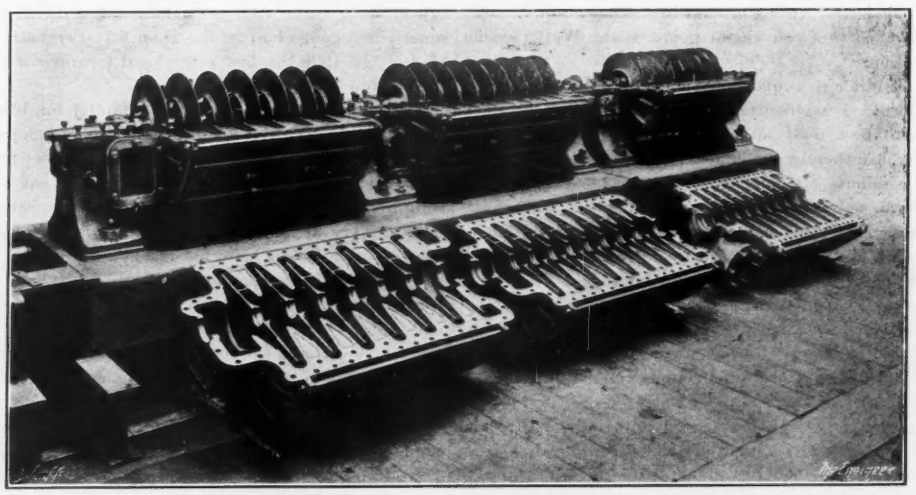


FIG. 2—TURBO-COMPRESSOR BUILT IN 1906 BY BROWN, BOVERI AND CO.

development of this type of machine may be awaited with interest.

COMPRESSORS IN THE CHEMICAL INDUSTRY.

The requirements of the chemical industry have, from time to time, been responsible for considerable technical developments in both reciprocating and centrifugal compressors. Questions of lubrication, materials of construction, and packing devices for pistons and piston-rods assume a greater significance than in the case of compressors for air.

For industrial processes, oxygen is normally stored in bottles at pressures varying from 1800 lb. to 2200 lb. per square inch. For charging the bottles a three-stage, three-cylinder compressor is used. All parts which come into contact with the gas must be made of materials which resist corrosion. The presence of free hydrogen or a slight amount of lubricating oil vapour in an oxygen compressor would be liable to cause a violent explosion through spontaneous ignition. For this reason, the use of oil as a lubricating medium is not permissible, and packing devices are used which do not require oil lubrication. Cup leathers are sometimes used, in other cases metal packing rings. Distilled water is sometimes employed as a lubricant, but this is not good, and necessitates frequent renewals of the third stage packing. In order to limit the temperature reached in the cylinder, a slow rate of compression is usually adopted for oxygen compressors, the rotational speed not exceeding about 130 r.p.m.

In this country the vertical compressor is most favoured for high-pressure work. Vertical compressors occupy less floor space, result in less cylinder wear, and during overhauling offer the advantage of vertical lifts. Another advantage, especially welcome with high-pressure single-acting compressors, is the method of cooling which is widely adopted with vertical compressors. A water tank is built on the entablature, and completely surrounds the cylinders. The cylinder construction can be simplified and cheapened, as no water jacket need be provided. The intercooler coils are conveniently placed in the tank and either surround the cylinders or are laid alongside them. As all high-pressure parts and joints are immersed in water, a leak can be quickly detected.

The compression of acetylene also calls for extreme care owing to the highly explosive nature of this gas. For pressures varying from 200 lb. to 300 lb. per square inch, a three-stage machine is used, the maximum ratio of compression per stage being kept down to about 2·7 in order to limit the temperature reached. A slow speed of rotation is also employed.

In 1905, Haber and Bosch introduced the synthetic ammonia process, in which a mixture of nitrogen and hydrogen is forced by a compressor through a vessel containing a catalyst. As the reaction is accompanied by a diminution of volume, the amount of ammonia formed in equilibrium with the nitrogen and hydrogen will increase with the pressure at any fixed temperature. In the Haber-Bosch process the compressors deliver the gas mixture at a pressure of about 3000 lb. per square inch. In the later Casale process, a pressure of 10,000 lb. per square inch is used, whereas, with a view to increasing still further the yield of ammonia, Claude employed a pressure of 14,000 lb. per square inch. To produce this pressure, a six-stage reciprocating compressor is used. It has been stated that in the sixth stage of the Claude compressor the ground plunger is packed with a hat leather, and cool working is ensured by making the plunger hollow and circulating water through it.

Without a doubt, one of the most impressive applications of gas compressors is that of the hydrogenation plant at Billingham. In the production of compressed hydrogen a combination of turbo-compressors and reciprocating compressors is used, each being employed in the region of capacity and pressure for which it is most suited. The so-called "H" gas is first compressed from 14·7 lb. to 24 lb. per square inch absolute by five-stage centrifugal boosters running at 3340 r.p.m. It is next compressed to 155 lb. per square inch absolute in twenty-three-stage centrifugal compressors running at 3600 r.p.m., direct coupled to 5000 H.P. steam turbines. The next stage of the compression is effected by three-crank, two-stage compressors which raise the pressure to 825 lb. per square inch. After the removal of CO_2 from the gas, it is compressed to a pressure of 3750 lb. per square inch in vertical three-crank, two-stage compressors. Both sets of reciprocating compressors are driven by steam turbines through double-reduction gears, the turbine speed being 4000 r.p.m. and the compressor speed 120 r.p.m. The compressors used in this plant are relatively large, *e.g.*, the intermediate reciprocating compressors deal with about 16,600 cubic feet of gas per minute and absorb 3500 H.P.

An interesting application of the turbo-compressor which has developed in the past few years arises in the production of nitric acid by the oxidation of synthetic ammonia. For various reasons this process is carried out more economically at a high pressure and a high temperature. Turbo-compressors are employed to compress the "nitrous" gases (a mixture of NO, NO_2, N_2, O_2, and a small amount of steam) to pressures which vary in practice from 30 lb. to 100 lb. per square inch gauge. In order to withstand the corrosive action of the gases, the compressor casing, shaft, and discs are made of rustproof chrome-nickel steel. So far as the writer is aware, these developments are due to the two well-known Swiss firms, Brown, Boveri and Co., and the Escher Wyss Engineering Works. A most interesting feature technically is that the hot residual gases are available at a pressure only slightly less than the charging pressure, and by passing them through a gas turbine the power recuperated is an appreciable fraction of that required to drive the compressor.

British Practice.

IN the following sections of this Supplement, the practice of compressor manufacturers in this and other countries is described. A large amount of information has kindly been made available to us by the manufacturers, and we have found considerable difficulty in arranging space for its reception, despite the fact that this Supplement has been enlarged by four pages beyond the size originally contemplated. Under the circumstances, rather than sacrifice the many drawings and other pictures that have been sent to us, we have preferred to keep the descriptive matter as short and concise as possible, and have in general concentrated our descriptions upon special or unusual features, leaving the drawings and other engravings to explain the design. Drawings are to a large extent self-descriptive, and usually provide far more information than any description could convey. Where, owing to lack of space, a selection has had to be made between a drawing or a photograph, we have usually chosen to reproduce the former. In this, the British section, a rough classification has been made for the convenience of readers under such headings as Vertical, Horizontal, Turbo, &c.

VERTICAL MACHINES.

In this country there can be no doubt that the most generally favoured reciprocating compressor is the vertical type. The design of such machines is founded upon the well-tried practice of steam engine design, modified where necessary to take the higher bearing loadings frequently encountered in compressor work. Vertical machines share with other reciprocating types the ability to reach very high pressures by multi-stage compression. But they have the individual advantages that they require very little floor space and that they can readily be constructed to be totally enclosed without the sacrifice of accessibility. The speeds at which they run are closely comparable with those of steam engines of equivalent size, and where steam is available a particularly compact unit can be arranged.

A typical example of an air compressor for general purposes—such, for instance, as the supply of air to pneumatic tools and appliances in a workshop—is illustrated in Fig. 3. It is a two-stage double-acting machine, built by Broom and Wade, Ltd., of High Wycombe. Double-acting machines are now very commonly used. Though they suffer to some extent the disadvantage that it is difficult to arrange for cylinder cooling as adequate as that possessed by single-acting machines, they are, of course, considerably more compact for the same output. But, as at the high speeds at which compressors now operate it is in any case difficult to arrange for efficient cylinder cooling, the disadvantage is slight. The unit illustrated is one of a range constructed to give free air capacities from 320 to 2500 cubic feet per minute delivered continuously against 120 lb. per square inch. Rogler-Hoerbiger plate valves are used, and are accommodated in chambers on the sides of the cylinders. This arrangement leaves the whole area of each cylinder head free for water cooling. Single-stage machines, in capacities from 4 to 800 cubic feet per minute and intended for continuous operation against pressures up to 120 lb. per square inch, are also built, and are suitable for intermittent operation against pressures up to 300 lb. per square inch.

The system of forced feed lubrication is of interest. An oscillating cylinder valveless plunger pump is used to circulate the oil, as shown in Figs. 4 and 5. The plunger A is directly driven by a crankpin B on the end of the crankshaft. It is mounted in the oscillating cylinder C, which communicates alternately with the suction and delivery ports. Before entering the pump *viâ* the pipe D, the oil passes through the filter E situated in the crankcase and accessible by the removal of the cover F. Oil from the pump is delivered through a copper tube to a spring-loaded by-pass regulator and distributed thence through suitable piping to the main bearings, and, *viâ* holes drilled in the crank webs, to the connecting-rod bearings. A portion of the oil is pumped to the piston pins and the cylinders are lubricated by oil thrown off by the cranks.

The firm's practice is to use only plate valves on the delivery side. Suction valves can, however, be alternatively of the mechanically operated mushroom type operated by cam gear. This arrangement has the advantages that the suction valves are opened and closed at fixed points in the stroke independent of the pressure within the cylinder; that they can be designed to have a large lift; and that they can be made to operate with considerable rapidity. Moreover, owing to the mechanical action, the effects of inertia of the valve and spring resistance, which are the causes of loss of efficiency when plate valves are used, are eliminated entirely. The makers claim that all their

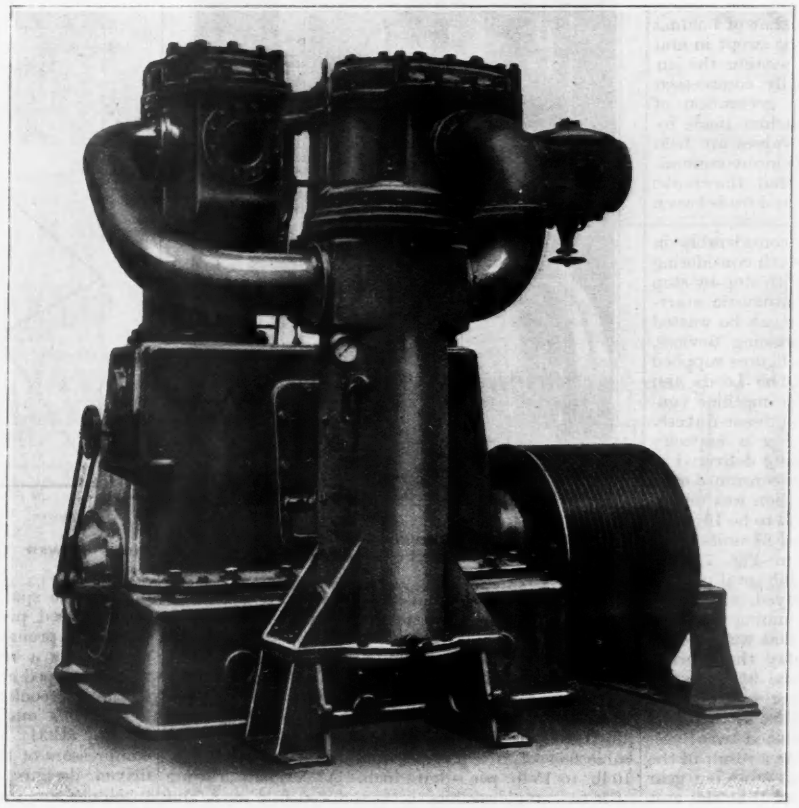


FIG. 3—TWO-STAGE, DOUBLE-ACTING AIR COMPRESSOR—BROOM AND WADE

single-stage machines attain a volumetric efficiency of 85 per cent. when operating against 100 lb. per square inch pressure and that 5 cubic feet of free air are delivered at that pressure for every B.H.P. absorbed.

Unloading.—In the majority of compressor applications the demand for the compressed gas is variable, whereas the compressor runs at a constant speed, and therefore gives a constant delivery. Some means have therefore to be provided whereby the amount of gas compressed can be balanced against the varying demand. Minor fluctuations of demand are smoothed out by the action of a gas receiver,

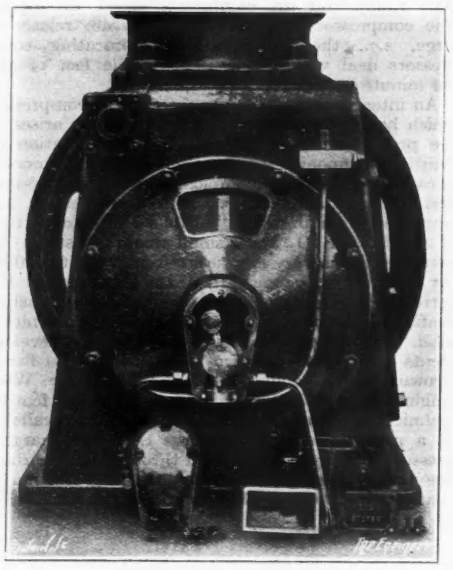


FIG. 4—VALVELESS PLUNGER OIL PUMP—BROOM

but, where the speed of the machine is invariable, larger variations can only be dealt with by some form of "unloader," which, while permitting the machine to continue to run, yet prevents it delivering gas to the receiver. Various unloading mechanisms are used. Normally, they are actuated automatically by a relay sensitive to alterations in the delivery pressure. The relay may consist of a gravity loaded plunger, beneath which the compressed air acts, a spring-loaded piston, a spring-loaded diaphragm, or a jet pipe device like the Reavell-Askania regulator. Whatever its design, it is caused to operate when a certain predetermined pressure is reached, and it causes the compressor to be unloaded by the movement of mechanism which holds the suction valves either open or closed. Alternatively, if the machine has several suction valves, as many large machines have, a group of relays, acting at different pressures, can progressively cause the suction valves to be operated in succession, and thus provide step-by-step unloading. Other arrangements are also possible.

The system of unloading by holding the suction valves open is generally preferred to that of holding them closed, as it causes cool air to be swept in and out of the cylinder. In the other system the air trapped in the cylinders is repeatedly compressed and re-expanded, with considerable generation of heat. In one small twin-cylinder machine made by Reavell and Co., Ltd., the suction valves are held closed, but a port is opened to provide intercommunication between the two cylinders, so that, the cranks being at 180 deg., the air is passed to and fro between them.

Where the maximum demand is considerably in excess of the average, it is usually worth considering the installation of a machine fitted with step-by-step unloading, or, alternatively, with automatic start-and-stop gear, as considerable power can be wasted in idle running with ordinary unloading devices. This fact is well illustrated by some figures supplied to us by Mr. Maurice Pickard, of the Leeds and Bradford Boiler Company, Ltd. The machine concerned was a modern two-stage compressor directly coupled to an electric motor, having a capacity of 100 cubic feet of free air per minute delivered at 100 lb. per square inch. As the power consumed each day appeared excessive, an investigation was undertaken. The power absorbed was found to be $16\frac{2}{3}$ electrical units per hour when loaded and $6\frac{2}{3}$ units when unloaded. A graph, reproduced in Fig. 7, was drawn to show what proportion of the total current consumed had been usefully employed, and what proportion had been wasted in idle running when the total consumption over a given period was known. For instance, if over an $8\frac{1}{2}$-hour day the average current consumption was found to be $9\frac{1}{2}$ units per hour, it is clear that the compressor was on load for only 17 min. in each hour, and that at this level of use only half the power consumed was usefully employed in compressing air. As a result of the investigation, automatic starting and stopping gear has been installed, and it is expected that the cost of the additional plant will be saved in reduced current consumption within a single year.

Steam-driven Machines.—Vertical compressors can be driven in practically any of the ways ordinarily adopted for machines of similar speed. Where, however, steam is to provide the motive power, a particularly neat arrangement can be attained by placing the air cylinders above the steam cylinders, and actuating both pistons from the same crank. An example of this design is shown in Fig. 11. The single-stage twin-cylinder gas compressor illustrated was supplied by Belliss and Morcom, Ltd., of Birmingham, for boosting up the gas pressure, as necessary, for a gas grid system. The cranks are at 180 deg., and the whole of the motion work is

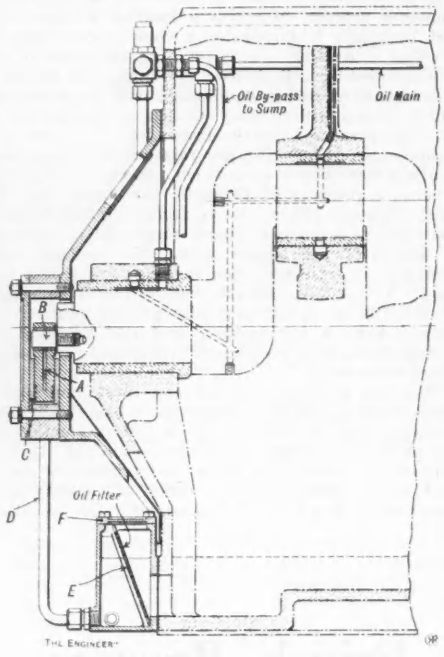


FIG. 5—LUBRICATION DIAGRAM—BROOM AND WADE

enclosed. The H.P. and L.P. steam cylinders, together with the valve chests between them, are made in one casting, and it will be noticed that the valve chests are slightly inclined from the vertical to allow for ample steam ports and passages. The air valves are arranged in valve chambers at the sides of the compressor cylinders, and are of the Rogler-Hoerbiger plate type, made in the firm's shops. Soft packing with a lantern ring is used for the gas rod glands, and any leakage is led back from the lantern ring to the compressor inlet. Metallic scrapers prevent oil being carried up the rods out of the casing and

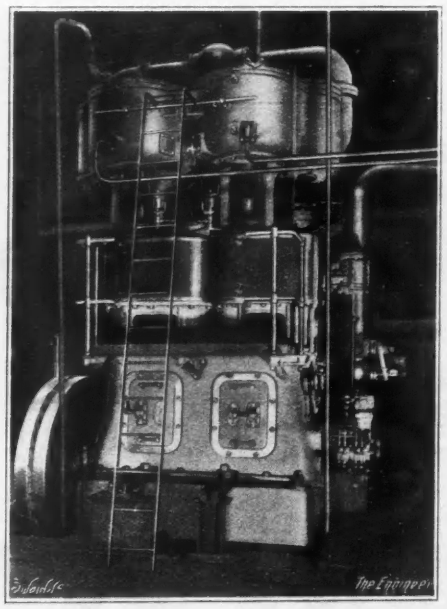


FIG. 6—STEAM-DRIVEN GAS COMPRESSOR —BROWETT LINDLEY

similarly prevent the movement of water of condensation along the rods. The steam cut-off can be varied by hand to suit the load, and a hand-operated speed-varying gear is also provided to meet the requirements of special conditions at the site.

Another steam-driven machine, made by J. Browett Lindley (1931), Ltd., of Letchworth, is illustrated in Fig. 6. It has a capacity of 3300 cubic feet of free gas per minute, at a pressure of 10 lb. to 15 lb. per square inch. A sectional drawing of a two-stage machine is reproduced in Fig. 8, and indicates how the various steam and air valves are arranged. On two machines of this kind recently supplied to the Bowes Coking Plant, Ltd., Jarrow, special control systems were applied to meet the particular conditions encountered. The machines are intended to pump gas from a gasholder supplied by coke ovens to another gasholder some 5 miles away in a neighbouring gasworks, and are fitted with three separate controls. The first, consisting of a diaphragm relay, actuates the main steam throttle valve and alters the speed of running in accordance with the variations in the pressure in the delivery main. If the demand for gas ceases altogether this control reduces the running speed to a predetermined minimum. A further rise in pressure in the main causes the second control, consisting of a relay of the weighted plunger type, to operate, and the compressor is then unloaded by releasing all gas compressed in the cylinders directly into the suction main. As, when the compressor came on load again, power would otherwise be wasted in recompressing the whole of the gas in the long delivery main, a non-return valve is fitted near the compressor. At first sight, these two controls seem sufficient to meet all eventualities, but, in fact, a third is necessary to protect the gasholder on the suction side. In the event of the supply from the coke ovens to this gasholder not being sufficient to meet the demand, the bell of the gasholder would fall. Were gas still to be withdrawn after it had reached its lowest position, there would be danger of its crown collapsing. But, owing to the fall in suction pressure and the tendency for the delivery pressure to fall, owing to the supply failing to meet the demand, the controls already described would tend to open the governor throttle and increase the speed of running, thus aggravating the conditions. The third control is of the jet pipe variety, and is provided to meet such circumstances. As the bell of the gasholder approaches its lowest position, it causes a valve in the suction main slowly to close, and the consequent fall in the suction pressure causes the relay to operate and a by-pass is thereby opened between the suction and delivery sides of the compressor and is maintained open until sufficient gas has entered the gasholder to provide an adequate supply.

A High-pressure Control.—Another control developed by the same firm may find mention here. It is of special importance in high-pressure machines. The firm's ordinary "unloader" acts to close the suction valves. But in the case of two-stage machines the air trapped in the high-pressure cylinder continues to be compressed at each revolution, almost to the full delivery pressure, with considerable wastage of power and generation of heat. The device, illustrated in Fig. 10, is designed to prevent that action. The relay A is the ordinary "unloader" control, which admits pressure air to the pipe B, when a predetermined maximum receiver pressure has been reached. This air then acts beneath the governor valve C to close it and prevent suction air reaching the cylinders. There is, however, in addition, an extension of the spindle below the valve C, which, when the valve is raised, allows air to pass along a

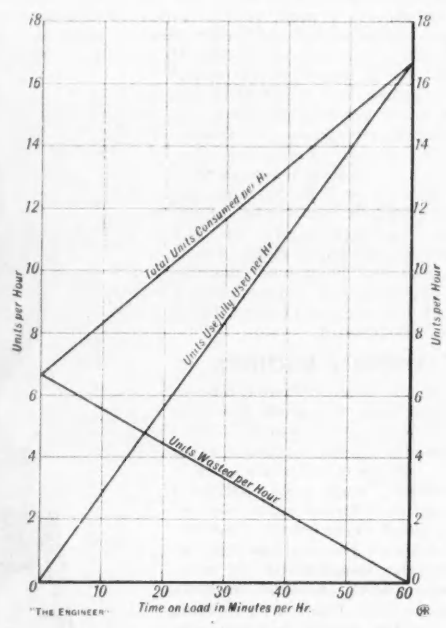


FIG. 7—POWER CONSUMPTION AND LOAD FACTO

pipe to the space in the main valve chest between two opposed pistons D D. These pistons are connected to prongs which act directly on the suction plates. As a result of holding open these valves, the air trapped in the H.P. cylinder is compressed only to the intercooler pressure at each stroke.

Materials and Valves.—The firm of J. Browett Lindley (1931), Ltd., makes a considerable range of compressors of the ordinary type besides the steam-driven designs illustrated. Single and two-stage machines are made in capacities up to 8000 cubic feet per minute for 30 lb. per square inch pressure, and up to 840 cubic feet for 120 lb. per square inch.

Larger machines outside the limits of the standard range are also made. In general design all the machines are similar. As an example of the kinds of materials used for the various parts of a modern compressor we print the particulars in Table I of the specification of a Browett Lindley machine. The valves used are of the Hoerbiger type and their design is shown by the drawing, Fig. 9. The working part of the valve is a thin plate of special steel which is held rigidly at the centre by an axial screw. The plate is ingeniously cut with the object of giving free elastic rectilinear movement with as small a resistance as possible. There are no wearing surfaces, and it is claimed that even after long service at high pressure no leakage can take place and, in fact, that the valve plate gradually adapts itself more and more truly to the highly finished surface of the seat. It will be observed from the drawing that a cushion plate is utilised to reduce the shock of opening. This plate, like the valve plate, is made of thin steel. The valve seat is of cast iron or steel, depending on the outlet pressure. Springs are fitted to the delivery valves to ensure a rapid return to the seating when delivery ceases. But no springs are fitted to the suction valves as the necessity for very rapid closure is not so great, whilst it is desirable that they should be lightly loaded in order that as much air as possible be drawn in on the suction stroke. An interesting point that is sometimes overlooked is that care should be taken in the choice of delivery valve springs that their periods or harmonics shall not coincide with the speed of the machine, as, should that occur, the valves will chatter.

"*Feather*" *Valves.*—In the machine illustrated in Figs. 12 and 14 a different type of valve is used. This compressor, which has a capacity of 1000 cubic feet per minute and works against a pressure of 100 lb. per square inch at 428 r.p.m., was manufactured by Worthington Simpson, Ltd., of Newark-on-Trent. It absorbs 190 B.H.P. and has a volumetric efficiency of 82 per cent. The valves, it will be noted from the drawing, are arranged around the circumference of the cylinder and not as in the machines so far described within a separate chamber communicating with the cylinder. This arrangement is claimed to have several advantages, the most important of which is that as the suction and delivery valves are on opposite sides a uniflow effect is obtained and the incoming air is not heated by passing over surfaces warmed by the compressed air just discharged. "Feather" valves are used which are entirely different from the Hoerbiger type. Each valve—Fig. 15—consists of a number of flat strips of flexible steel, a seat, and a guard. Each of the strips, when seated, covers a somewhat smaller slot in the valve seat and is located by a recess in the valve guard without, however, being rigidly held at any point. The seat has a perfectly flat ground face, and the flexibility and freedom of movement of the strips ensure full contact with the seat throughout their length. The strips do not

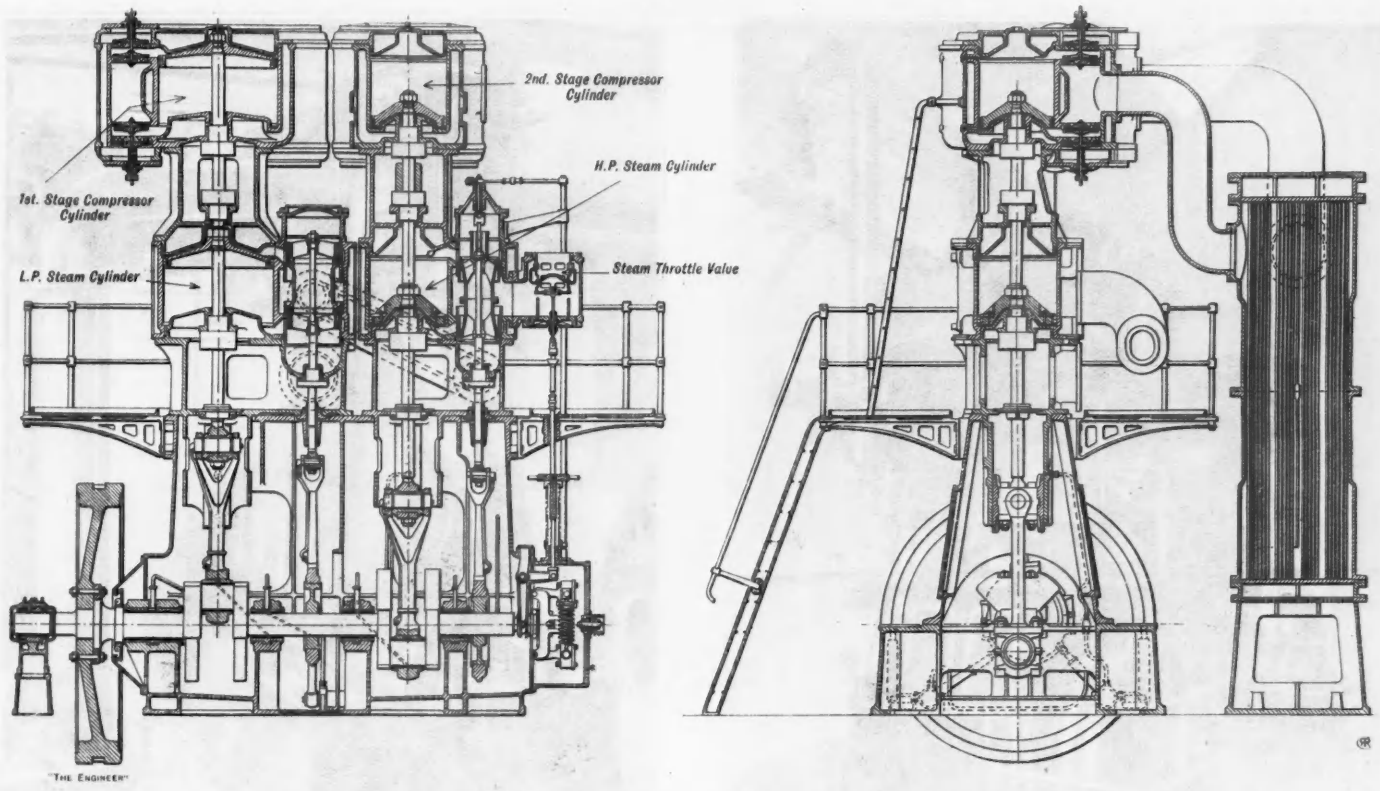


FIG. 8—ARRANGEMENT OF STEAM-DRIVEN TANDEM TWO-STAGE GAS COMPRESSOR—BROWETT LINDLEY

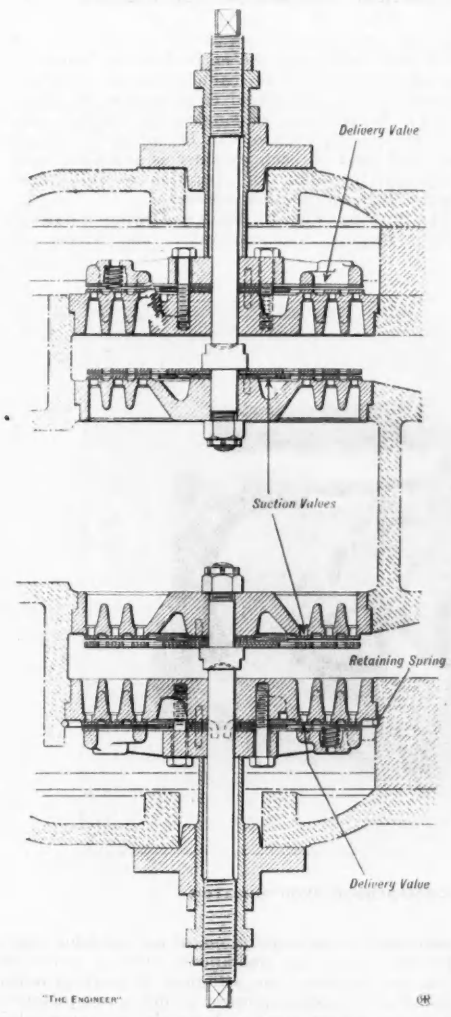


FIG. 9—HOERBIGER VALVES—BROWETT LINDLEY

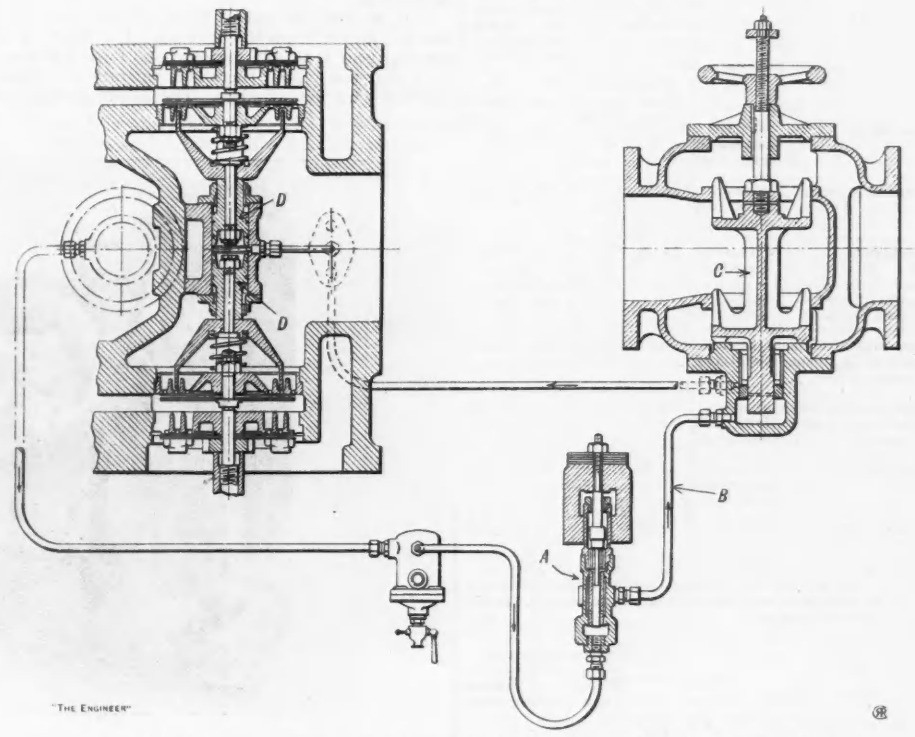


FIG. 10—UNLOADING DEVICE FOR HIGH-PRESSURE MACHINES—BROWETT LINDLEY

require any springs for closing and are perfectly free to lift from the seat. As the recesses in the valve guard are accurately machined to a curved profile, the valve opens by a gentle flexing movement of the strips against the profile of the guard, the ends of each strip remaining almost in contact with the seat, and the maximum lift occurs in the centre of the strips. There can be no sudden impact such as occurs with a direct lifting valve. Owing to the lightness of the strips and the absence of impact a high lift is possible, and the valves are free from leakage and are quiet in operation. In Fig. 14 the valves as shown in section should be imagined turned axially through 90 deg. They are, in fact, so mounted that the strips are vertical and not horizontal.

The mechanical construction of the compressor can be followed from the drawing. The whole of the running gear is totally enclosed and force lubricated by a gear pump, and there is a separate mechanical lubricator for the cylinders. The output is regulated by an unloader operating to hold open the suction valves. Normally, compressors are fitted with three-step regulation giving full load, half load, and no-load operation. For this purpose the unloaders at the two ends of the double-acting cylinders are operated by two relays with independent adjustment. On the pressure reaching a predetermined point, the first relay functions, unloading one end only of both high and low-pressure cylinders, thus reducing the output by one half. A further rise in pressure operates the second relay completely unloading the compressor. On the pressure falling the reloading is similarly accomplished in steps. With this multi-step regulation system under normal operating conditions stresses resulting from the operation of the regulator and disturbances in the electric main are much less than when the entire load is thrown on and off in one step. It is clear also that the three-step system reduces the actual consumption of electric power. In the case of single-stage Duplex compressors five-step control can be supplied. In this case each end of each cylinder is unloaded independently, providing for operation at full, three-quarter, half, quarter, and no load.

The drawing, Fig. 15, besides showing the design of a "Feather" suction valve, also shows the arrangement and connections of an unloader relay. The latter is of the well-known form in which air from the receiver, on attaining a predetermined pressure, forces back a plunger against spring pressure. The air then flows to a chamber within the main valve assembly, where, acting upon another plunger, it pushes outwards a fork-shaped piece, the separate prongs of which act upon the flexible steel strips of the valve.

Air-cooled Machine.—In general air-cooled compressors are of small size and suffer to some extent

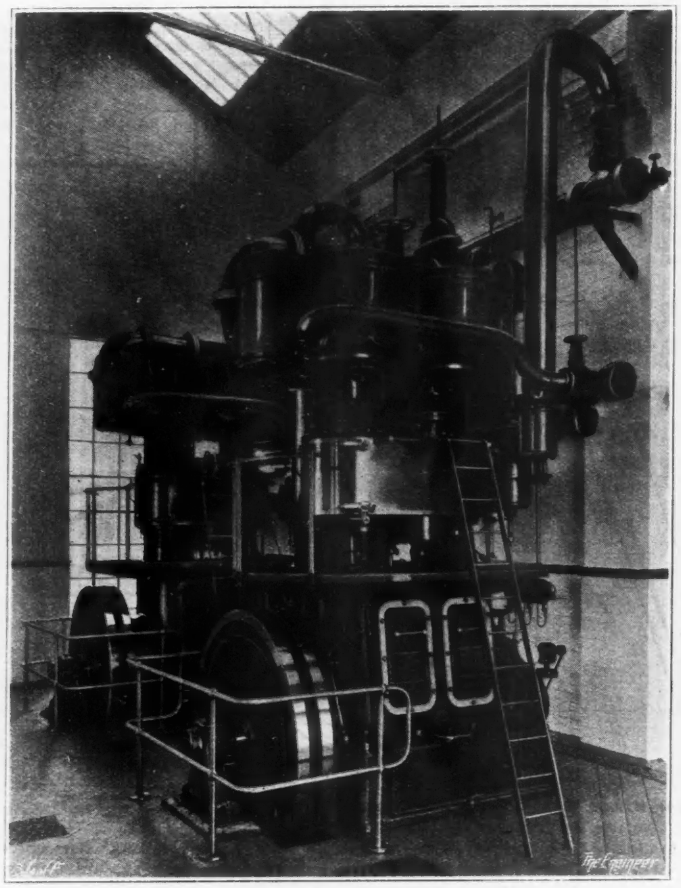


FIG. 11—STEAM-DRIVEN GAS BOOSTER—BELLISS

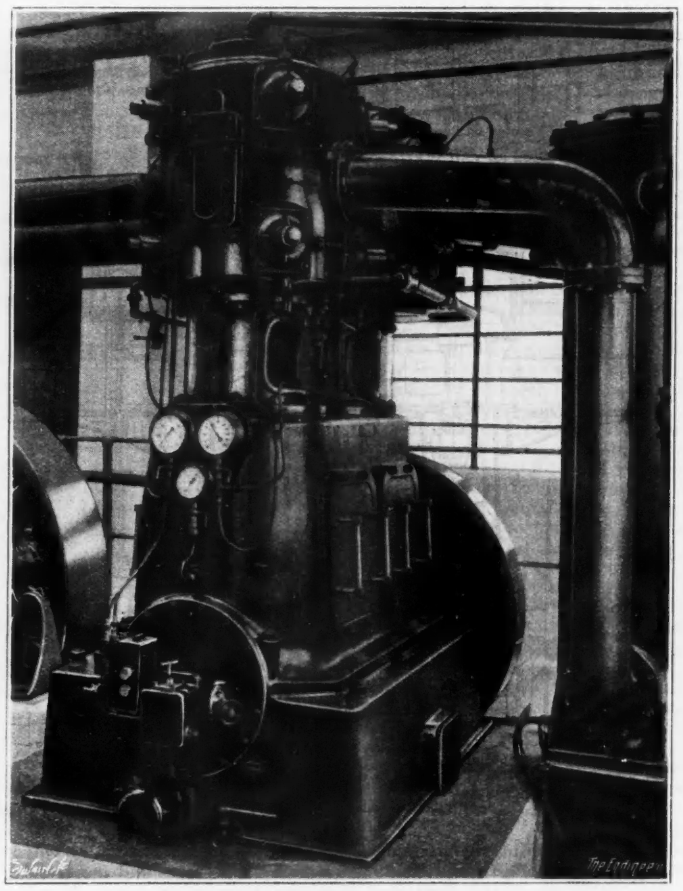


FIG. 12—TWO-STAGE VERTICAL COMPRESSOR—WORTHINGTON

TABLE I.

Part.	Material.	Tensile strength.	Minimum yield point.	Minimum elongation in 2in.	Minimum reduction in area
		Per sq. in. Tons.	Per sq. in. Tons.	Per cent.	Per cent.
Crankshaft	Siemens Martin acid mild steel	34–38	19	25	35
Connecting-rods ...	Siemens Martin acid mild steel	28–32	17·5	25	25–30
Piston-rods	0·4 carbon steel	38–42	21	20	45
Crosshead bolts, crank pin bolts	3 per cent. nickel steel	48	34	27	59
Excentric clip bolts and studs, balance weight studs	3 per cent. nickel steel	48	34	27	59
Main bearing bolts and studs, foundation bolts ...	Siemens Martin acid mild steel	28–32	17·5	25	25–30
Coupling bolts ...	Siemens Martin acid mild steel	34–38	19	25	35
Crosshead steps ...	Gun-metal	14–15	7–8	15	12–15

Steel Castings:—Tensile, 35–40 tons; minimum elongation, 20 per cent. in 2in.; cold bend test, section 1in. diameter, length 9in., inside diameter 2½in., angle of bend, 120 deg. without fracture.

			Transverse test.		
			Size of bar.	Load.	Deflection.
		Per sq. in. Tons.		Cwt.	Inch.
Bedplates, frames, &c.	Cast iron	11	1in. sq. × 12in. long	21	0·15
Cylinders, covers, intercooler, &c.	Cast iron	12–14	1in. sq. × 12in. long	26–28	0·15

Intercooler tubes: Seamless brass, 70 per cent. copper, 30 per cent. spelter; 35–36 tons tensile; elongation, 12 per cent. on 2in.
Tube plates: Yellow brass, 60 per cent. copper, 40 per cent. zinc.

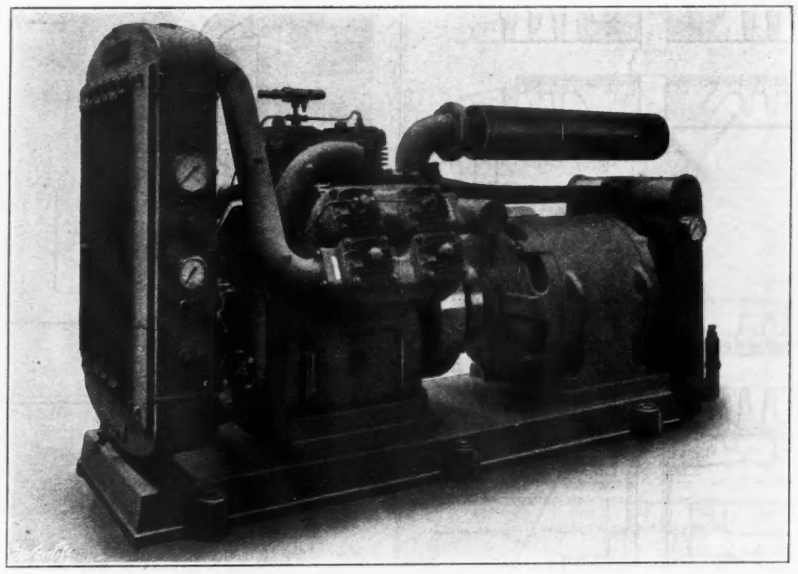


FIG. 13—AIR-COOLED TWO-STAGE COMPRESSOR—WORTHINGTON

in efficiency as compared with water-cooled machines. Worthington-Simpson, Ltd., however, produce two-stage air-cooled machines of the type shown in Fig. 13 in units giving up to 500 cubic feet of free air per minute at pressures up to 150 lb. per square inch and claim that overall efficiencies fully equal to water-cooled machines are attained. On two-stage machines, such as that illustrated, the fan draws air vertically and the other horizontally. This design is adopted by the Ingersoll-Rand Company, Ltd., of 165, Queen Victoria-street, London, a concern which builds a very large range of compressors from the smallest to the very largest sizes and whose products are more fully described in the American section of this Supplement. A small machine of the type mentioned is illustrated in Fig. 16, driven by multiple jackets around the cylinder, this rise in temperature approximates to that to be expected from adiabatic compression. By increasing the volume of the gas to be dealt with the rise in temperature causes an increased consumption of power so that where high pressures are to be attained it is desirable to compress in two, three, four, or more stages and to cool the air in intercoolers, as far as possible, between the

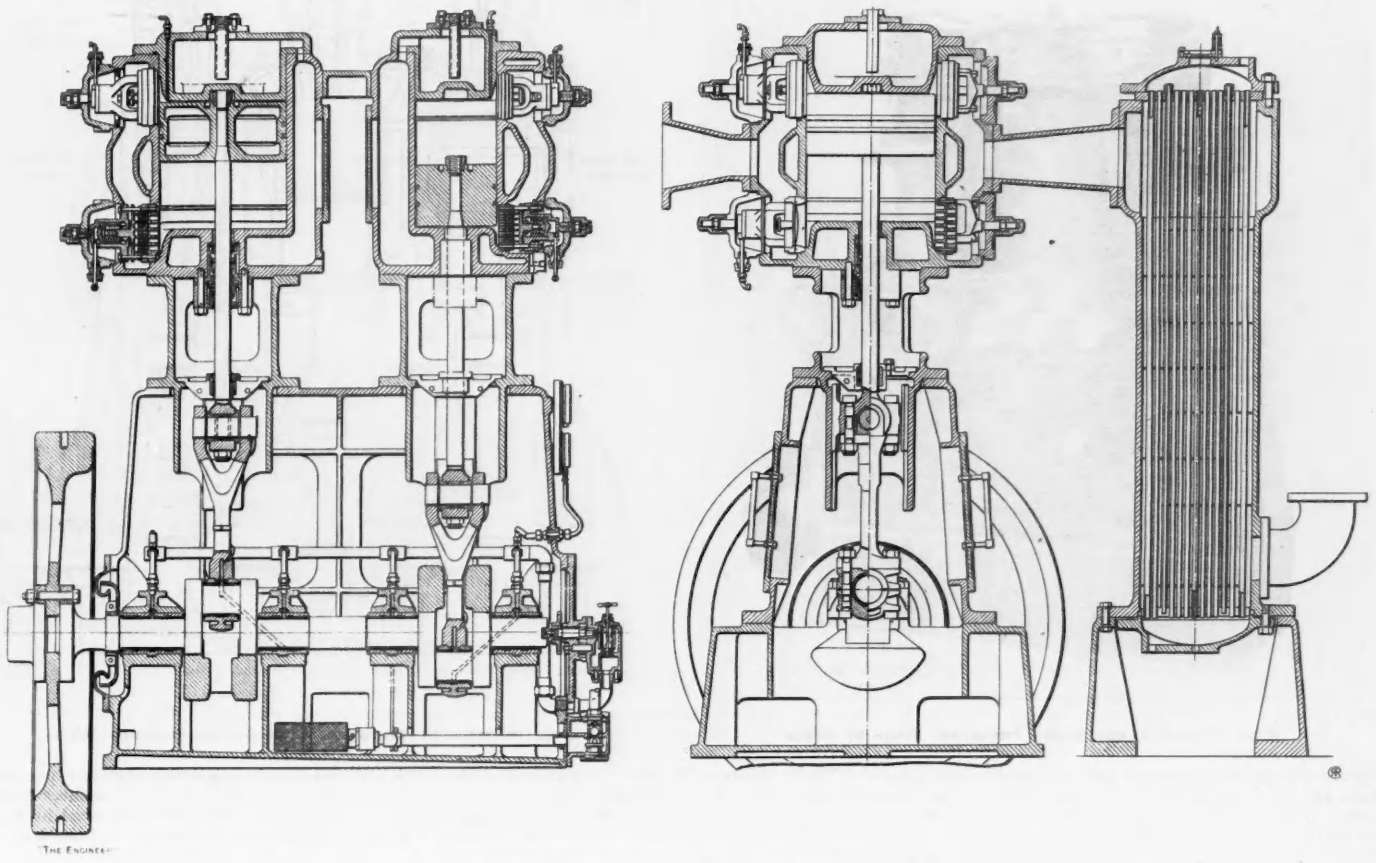


FIG. 14—GENERAL ARRANGEMENT OF TWO-STAGE VERTICAL COMPRESSOR—WORTHINGTON

through an air-cooled intercooler and delivers it over the cylinders and cylinder heads, and there is also an air-cooled aftercooler served by a second fan at the further end of the driving motor. The volumetric efficiency is 82·5 per cent. and the power consumption of a 350 cubic foot, 120 lb. per square inch machine at 960 r.p.m. is 82 B.H.P. There are two cranks. Four low-pressure cylinders are arranged at an angle

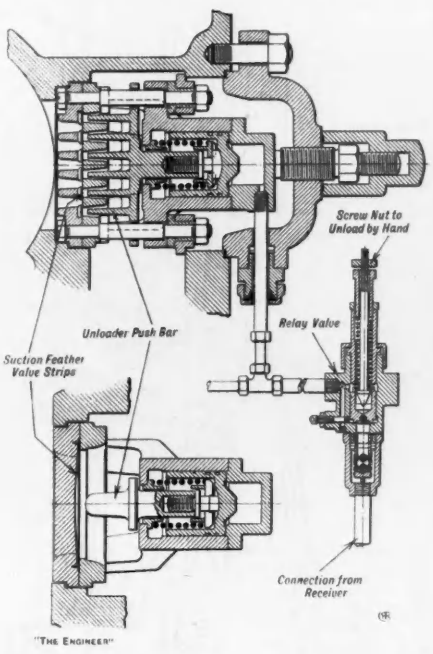


FIG. 15—"FEATHER" VALVE—WORTHINGTON

to the vertical in banks of two, and two high-pressure cylinders are placed on the vertical line between them. Articulated connecting-rods with the master rod directly coupled to the H.P. line are used. Forced lubrication is arranged to all parts.

Angle-Compound Machine.—Instead of placing the high and low-pressure cylinders in tandem on one crank or side by side on two a single crank arrangement can be adopted with one cylinder arranged vee belt by an electric motor. The low-pressure cylinder is disposed vertically and the high-pressure horizontally. An intercooler is arranged between the two, but is only partially visible in the engraving. It is claimed that this construction provides a more perfect operating balance than it is possible to attain with a straightforward horizontal or vertical arrangement. Recently the development of large-size roller bearings has permitted the use of heavy duty tapered roller main bearings. Piston-rod packings are metallic and the pistons are made of chrome-nickel iron. All the valves are of the channel type, described in detail

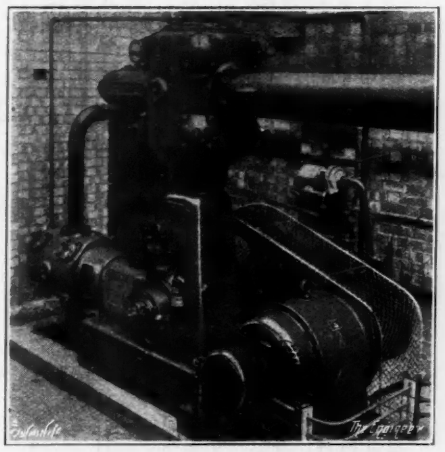


FIG. 16—ANGLE-COMPOUND COMPRESSOR —INGERSOLL

in the American section. They consist of strips of steel of channel section held against the slotted valve plate by steel strip springs which rest in the channel and bear against fixed buttresses at the back. In the free attitude the springs are curved and when the channel strips are lifted to open the valve they are flattened out against the buttresses. These machines are available in a range of sizes with actual deliveries of 500 cubic feet per minute upwards.

MULTI-STAGE MACHINES.

As is well known the temperature of the air compressed in a high-speed machine is considerably increased. Despite the presence of the water cooling stages. Besides a saving in power the multi-stage arrangement has certain practical advantages. Were an attempt made to compress to a high pressure in a single cylinder the volumetric efficiency would suffer unless an impossibly small clearance were left between the piston and the cylinder head at inner dead centre. Whereas in the multi-stage machine the final stage cylinder is of small diameter and the clearance can have a reasonably large dimension. Multi-stage machines are made by many manufacturers and the arrangement of the stages permits of many variations.

A special application of the three-stage machine is that of charging the starting air bottles for oil engines. The firm of G. and J. Weir, Ltd., of Glasgow, makes a range of such machines up to capacities of 720 cubic feet of free air per minute for pressures from 325 lb. to 600 lb. per square inch. The smaller units of this range have single cranks only. First-stage compression is performed above the main piston, second-stage in the annular space between the cylinder and the reduced diameter skirt of the piston, and final compression by a plunger mounted on the head of the main piston and working in a small diameter cylinder in tandem with the main cylinder. Larger machines have twin cranks. For pressures not exceeding 450 lb. per square inch, a range of similar two-stage machines is made. For higher pressures four-stage machines similar in design to that shown in Fig. 19 can be used. As the first and second-stage cylinders are both double-acting, a neat, compact design results. Although the centre distance between the cylinders is somewhat limited, the makers claim that the valves are all accessible. First and second-stage valves are mounted on the front and back of their respective cylinders, while those for the other two stages are let into valve bosses at the top. In order to retain rigidity the first and second-stage cylinders are combined in a monobloc casting which is spigoted into the top of the crank case. This design of machine can be arranged for a drive by a high-speed electric motor through gears which are accommodated in an extension of the sole plate and crank case. Such an arrangement economises weight, a matter of considerable moment on shipboard.

In cases where economy in power consumption is of importance, such as an industrial plant which is required to run for long periods, high-pressure machines of five stages are often preferred for large capacities. The first cost of such a machine is, of course, higher than that of a four-stage machine of the same capacity, but in

many cases the economy in running costs outweighs the greater initial capital expenditure.

Such a machine, made by G. and J. Weir, Ltd., of Glasgow, is shown in Figs. 17 and 18. In order to ensure accurate balance it is designed on three cranks, the first, second, and fourth stage compression cylinders being mounted on each of two cranks, while the third and fifth stage compressions are carried out on the third crank. The duplication of first and second-stage cylinders obviates the necessity for utilising large diameter pistons, and thus reduces the weight of the moving parts and produces a smoother running machine. Inter-stage and after coolers are fitted, those of the first, second, and fourth stages each serving the double cylinders of their respective stages. First, second, and third-stage coolers are of the solid-drawn, straight-tube type, while the fourth and fifth stages are built with solid-drawn coils. These machines run at speeds of 300 to 350 r.p.m., and are suitable for direct drive by electric motor, steam engine, or internal combustion engine.

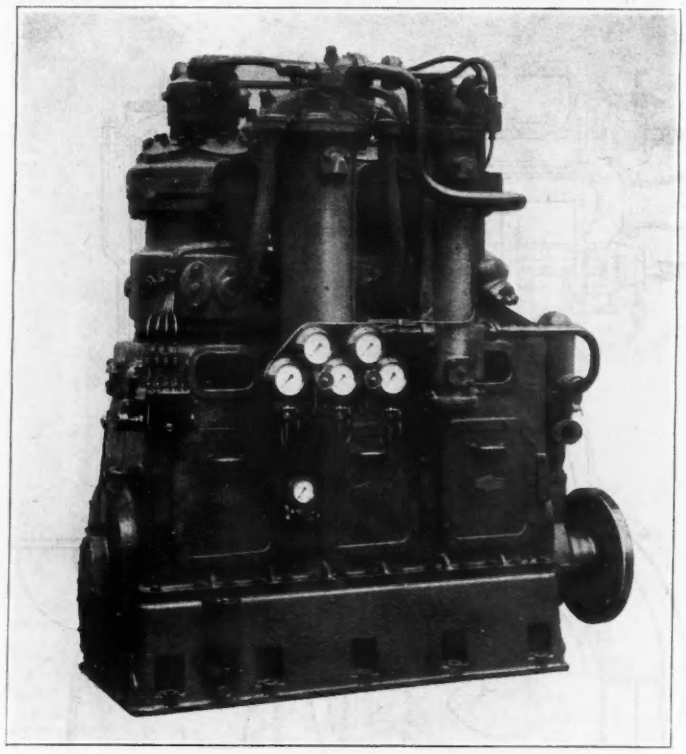


FIG. 17—FIVE-STAGE HIGH PRESSURE MACHINE—WEIR

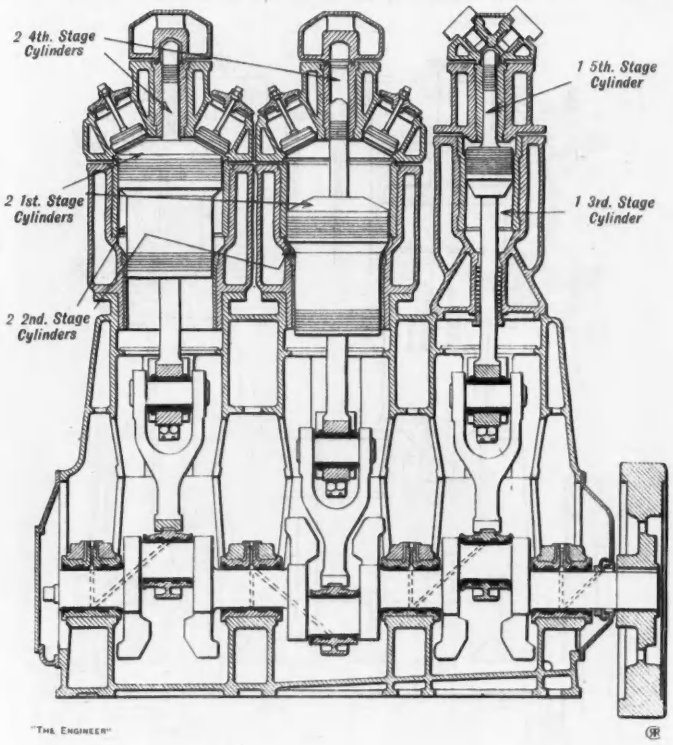


FIG. 18—SECTION THROUGH FIVE-STAGE MACHINE—WEIR

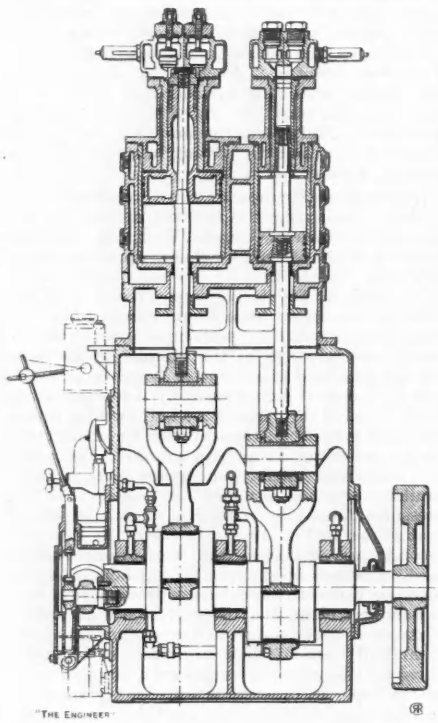


FIG. 19—FOUR-STAGE COMPRESSOR—WEIR

GAS COMPRESSORS.

CO_2 Machines.—Carbon dioxide is used for many other purposes besides refrigeration systems and in the form of dry ice. It is required for the manufacture of artificial mineral waters, for carbonating, clarifying and raising beer, in the manufacture of sodium carbonate and white lead, in sugar refining, and for bread making, to mention only a few applications. An interesting example of a plant recently installed for the manufacture of dry ice is that at the Carbo-Ice Factory of the S. Wales and Monmouth Trading Estates, Ltd., Treforest Estate. A four-stage two-crank totally enclosed compressor and a three-stage two-crank totally enclosed booster were both supplied by Reavell and Co., Ltd., of Ipswich, to that factory. The compressor is designed to deal with 1650 lb. of gas per hour compressed to 1200 lb. per square inch, and the booster, which is used for recirculating at a rate up to 3300 lb. per hour, aspires the gas at any pressure between 35 lb. and 50 lb. per square inch and delivers it at 1200 lb. per square inch. Each unit is driven by a Belliss and Morcom two-crank compound steam engine. The compressor speed can be arranged to be anything between 400 and 440 r.p.m., whilst the booster will run at varying speeds between 310 and 400 r.p.m., depending upon the pressure at which the gas is admitted to the machine. Sectional drawings of the booster are reproduced in Fig. 20. The makers state that normally a three-stage compressor and a two-stage booster would have been satisfactory for the work undertaken. But it was desired to keep down temperatures during compression, so an extra stage was added to each machine.

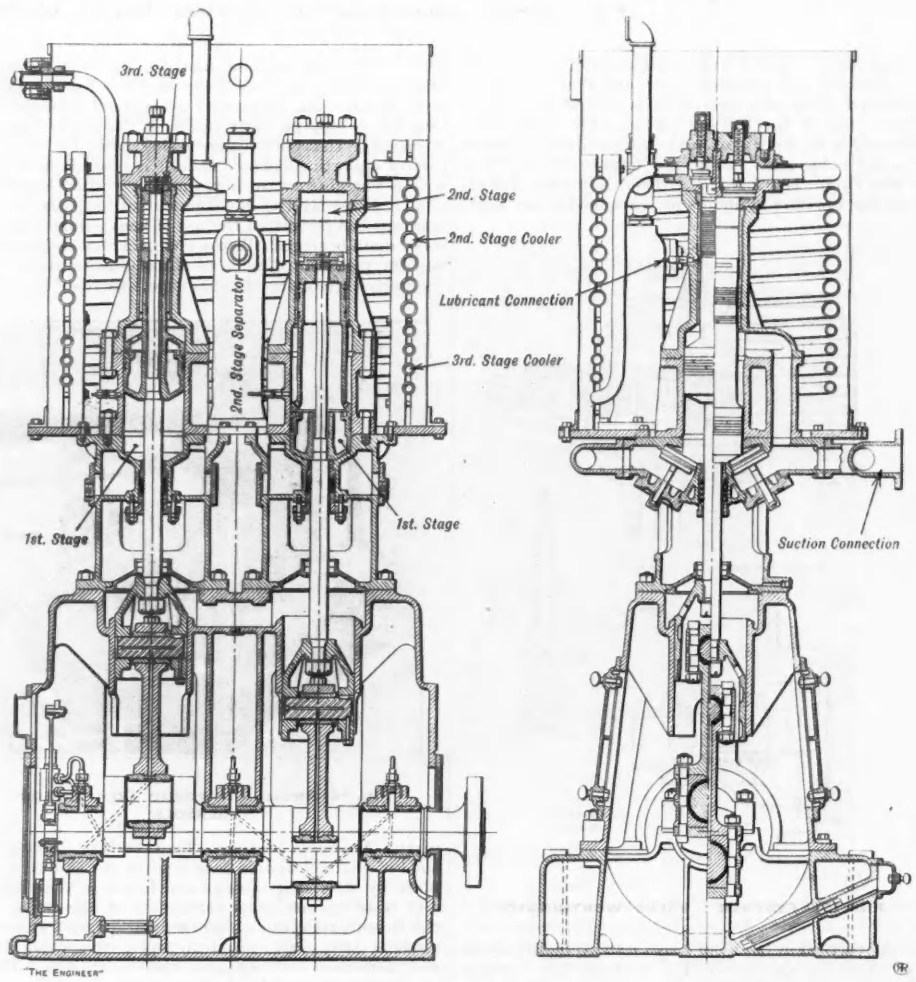


FIG. 20—SECTIONS OF THREE-STAGE CARBON DIOXIDE PRESSURE BOOSTER—REAVELL

Large vertical coolers are arranged between the first and second stages of the booster and between the first and second and second and third stages of the compressor. Cooling before the final stage in each machine is effected by coils in an open tank around the cylinders, as shown in the drawing, through which water constantly flows. There are separators arranged in conjunction with each cooler and a final separator in each delivery pipe. The two machines are similar in design. The compressor has two stages of compression on each crank, whilst in the booster the entering gas is first compressed under the pistons on both lines and the second and third stages are arranged above, one on each line.

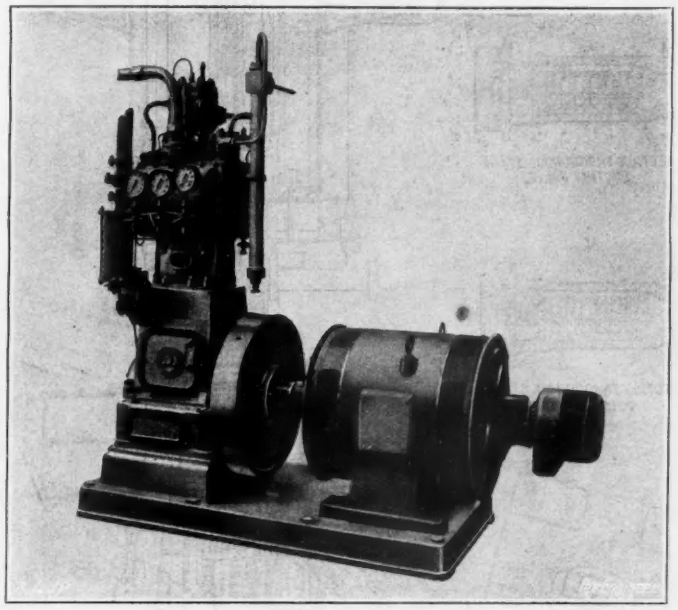


FIG. 21—CARBON DIOXIDE RECOVERY MACHINE—BROTHERHOOD

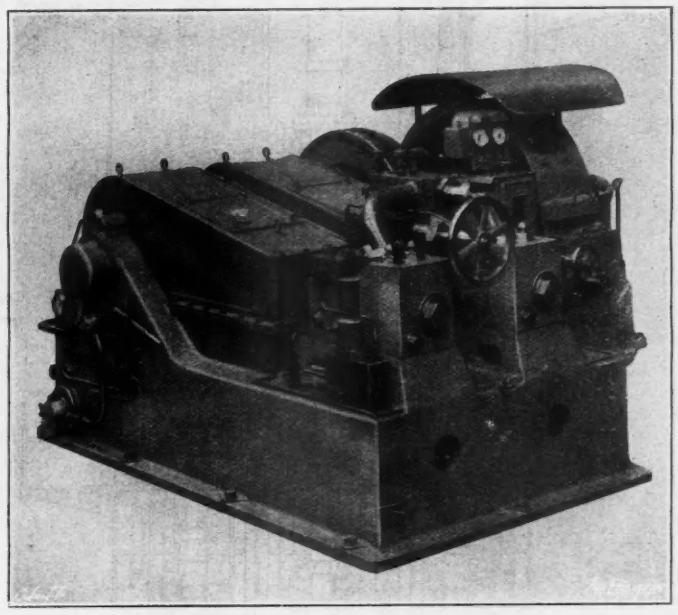


FIG. 22—HORIZONTAL AMMONIA COMPRESSOR—HALL

As carbon dioxide finds so many uses it is becoming profitable to distilleries and other works in which the gas is formed as a by-product to recover it and sell it stored in gas bottles. The carbon dioxide recovery machine illustrated in Fig. 21 and arranged to be particularly suitable for such works is made by Peter Brotherhood, Ltd., of Peterborough, a firm which manufactures reciprocating compressors of all types up to very large sizes. The machine is similar in design to compressors made by the firm for a variety of other purposes. The complete CO_2 recovery plant consists of a primary depositor and scrubber, acid towers, washing towers, a condenser, and bottling equipment; but we lack space which would allow us to describe it in detail. The gas is collected from the vats in several ways, that very usually adopted being the use of an inverted funnel, the edges of which are immersed in the liquid. It is partially cleansed in the depositor and scrubber, highly compressed by the compressor, purified in the acid and washing towers, liquefied in the condenser, and finally passed into the bottles. The compressor is a single-crank machine and has three stages. First and third-stage compression occurs on the upstroke and second-stage on the down. A mechanical drip feed lubricator supplies a small quantity of oil to lubricate the pistons, and when the gas is required for mineral waters the use of medicinal paraffin is recommended. The design is such that no oil from the crank case can possibly enter the cylinder by way of the piston-rod.

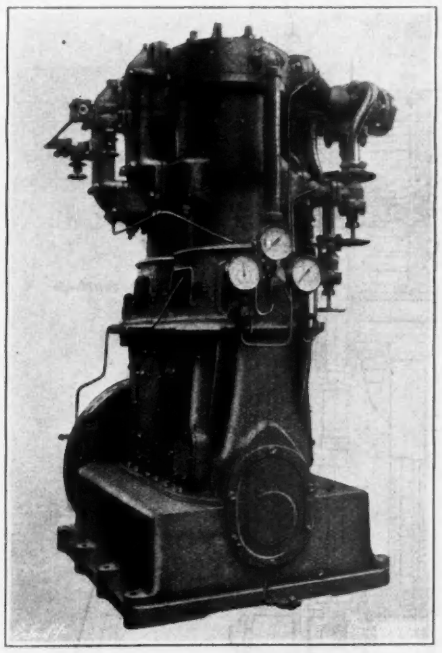


FIG. 23—TWO-STAGE AMMONIA COMPRESSOR —BROTHERHOOD

Ammonia.—Ammonia is principally used in connection with refrigeration plants and there are a number of manufacturers making compressors for that purpose. In general their design is similar to that of normal machines, but it is necessary to take precautions against gas leakage and against the possibility of liquid ammonia finding its way into the cylinder. The two engravings, Figs. 23 and 24, show typical examples of the many types of machines made by Peter Brotherhood, Ltd. The first illustrates a two-stage two-crank machine with a displacement of 460 cubic feet per minute at 300 r.p.m., whilst the drawing shows the design of a series of three and four-cylinder machines with displacements between 180 and 240 cubic feet per minute. There are a number of points of interest which may be noticed in the drawing.

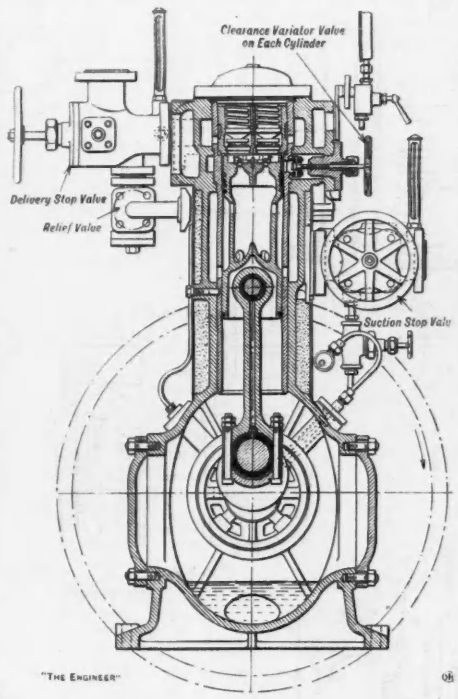


FIG. 24—SECTION THROUGH AMMONIA COMPRESSOR —BROTHERHOOD

Ammonia is drawn in from the suction port into the annular space around the reduced diameter skirt of the piston and passes *vid* holes cut in the skirt into the hollow interior of the piston. The head of the piston is recessed to take the suction valves, which are of Hoerbiger type. The lower part of the skirt of the piston is enlarged to the full diameter and carries an oil scraper ring. Ammonia is delivered out of the cylinder through delivery valves in the cylinder head. These valves consist of steel rings of channel section held down by light ribbon springs. Each valve and its housing is held in place by a strong steel spring which, in the event of liquid ammonia being present, allows the whole assembly to lift and thus permits the liquid to be passed without damage to the machine. These multi-cylinder machines can by a suitable arrangement of the ports in the cylinders be supplied for working on as many different suction pressures as there are cylinders. For variation of the duty of the individual cylinders a variable clearance control actuated by an external hand wheel is fitted as shown on the drawing.

The horizontal machine illustrated in Fig. 22 is made by J. and E. Hall, Ltd., of Dartford, a firm which specialises in refrigeration machinery and which is particularly interested in that required on shipboard. The horizontal arrangement has obvious advantages when the machine is to be placed in confined "'tween decks." It has, too, the advantage that the compressors can be mounted on upper decks, where, the makers state, vertical machines may tend to produce vibration. Single-acting cylinders are used and the valves are of the poppet type, spring loaded. All motion work is totally enclosed under removable covers. A baffle plate at the compressor end of the cover forms a separate compartment for the compressor gland. Forced lubrication to all the bearings is provided by an oil pump driven from the end of the crankshaft. A hand pump is fitted for priming the system before starting up. The following table gives particulars of the smallest and largest machines in the range and

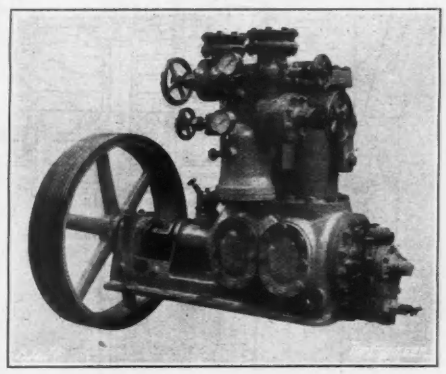


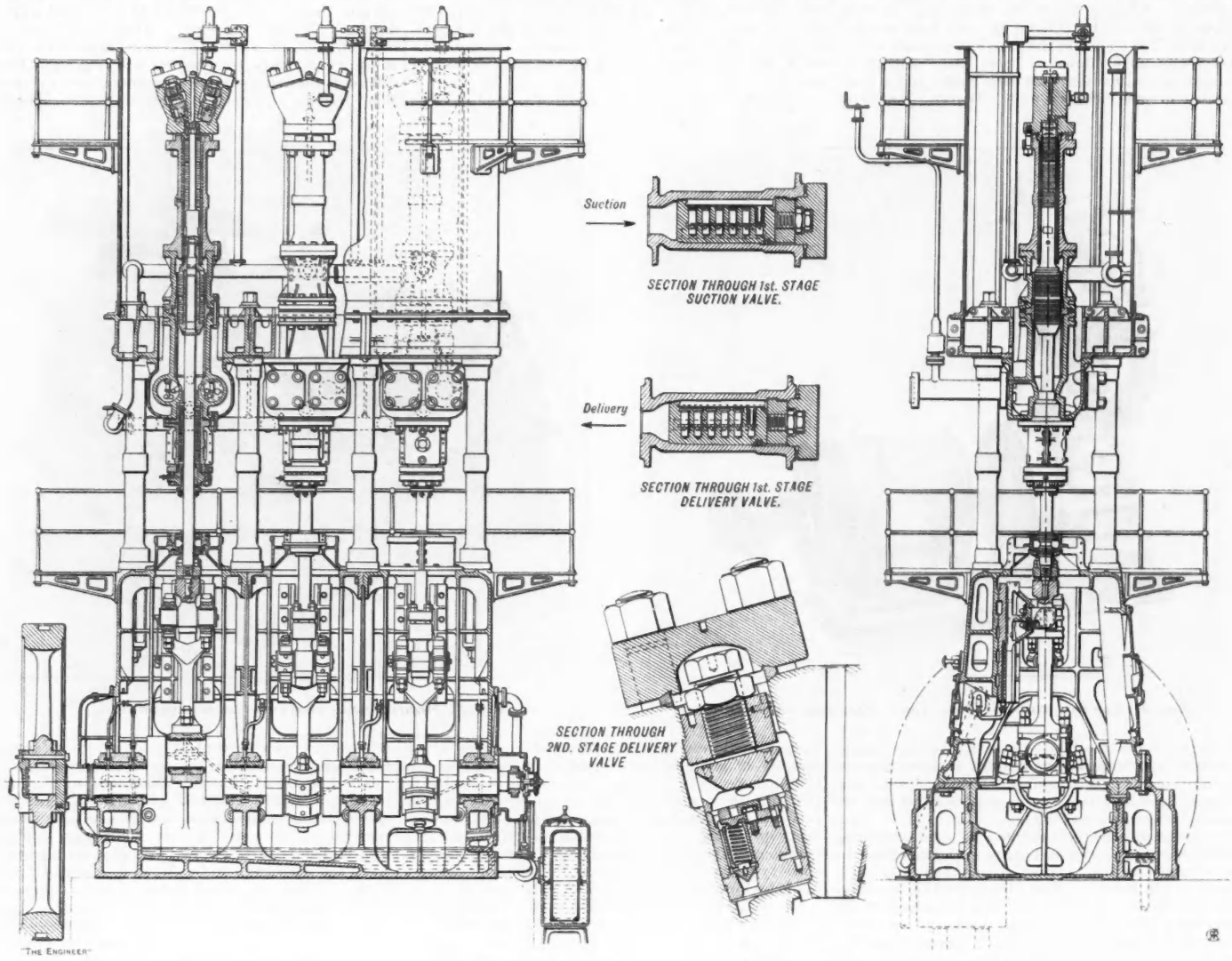
FIG. 25—"FREON" GAS COMPRESSOR—HALL

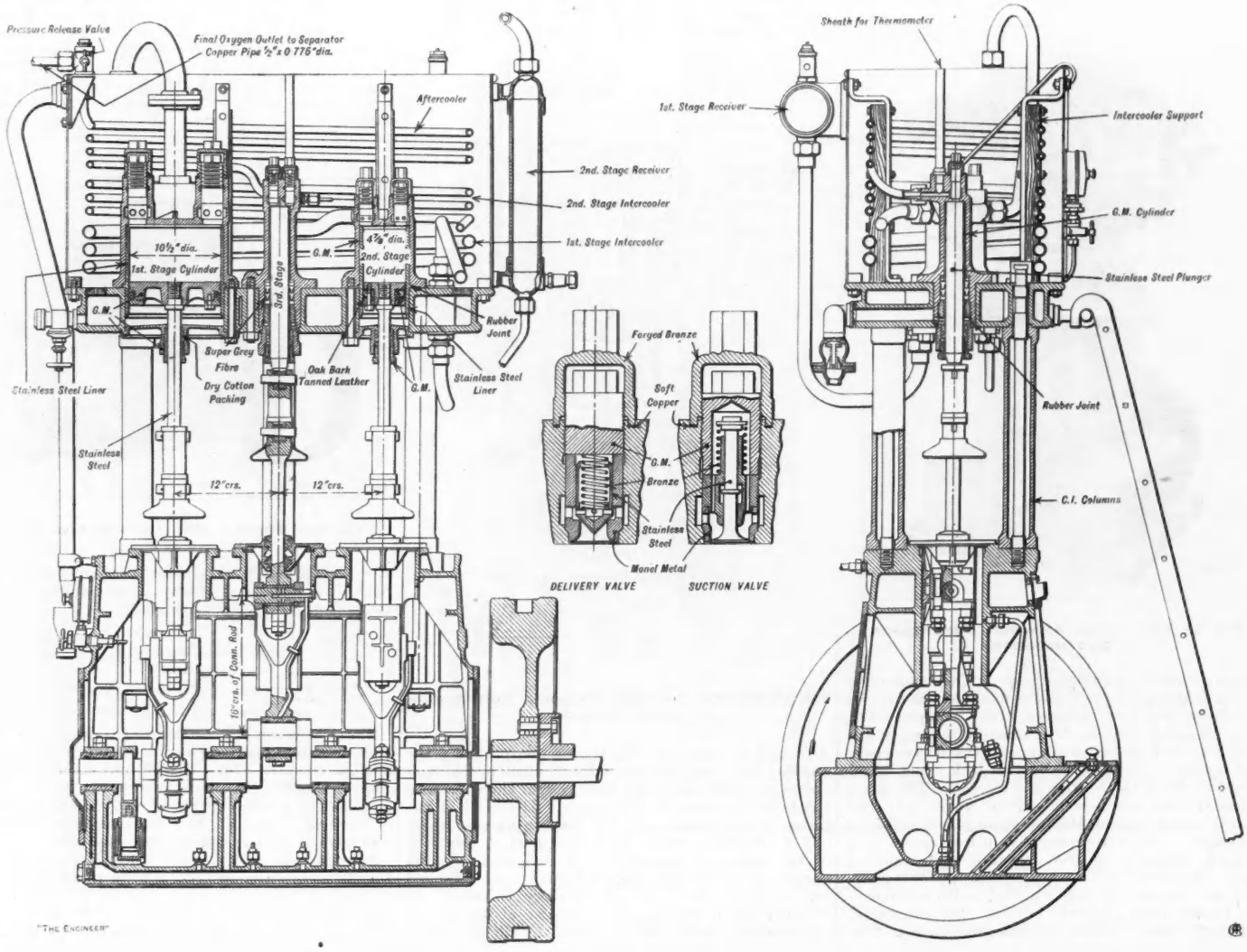
of the refrigeration duty in British long tons (13,440 B.Th.U. per hour) at 86 deg. Fah. condenser gauge and 5 deg. Fah. evaporator gauge :—

Width	5ft. 3in.	... ...	8ft.
Length	8ft.	... ...	11ft. 6in.
Height	5ft. 9in.	... ...	7ft.
Weight	4½ tons	... ...	11 tons
R.p.m.	350	... ...	250
Horse-power	90	... ...	190
Refrigeration, tons	23½ to 28½	... ...	76½ to 86½

Freon.—Another material which has recently been developed for the refrigeration cycle is Freon, and a machine made by J. and E. Hall, Ltd., of Dartford, for compressing this gas is illustrated in Fig. 25. Suitably modified, it is also capable of compressing ammonia or methyl chloride. The machine is constructed robustly, so that it can be used in situations where light scantlings might tend to transmit and aggravate the noise of machinery, and is made in a range of five sizes with cylinder bores of 4in. to 8in. Splash is depended upon for the lubrication of all working parts in the crank case of the smallest machine, but

HIGH PRESSURE GAS AND THREE-STAGE OXYGEN COMPRESSORS—BROTHERHOOD





the larger sizes have forced lubrication. Trunk pistons are used with a central suction port and gas sealing rings are fitted above the gudgeon pin and an oil scraper ring below. Normally ring plate valves are used both for suction and delivery, but for exceptionally low temperature work poppet delivery valves are fitted. Suction and delivery ring valves are interchangeable. Each cylinder has a spring-loaded safety head. Normally grooved fly-wheels suitable for multiple vee belts are fitted, but other forms of drive are equally suitable.

Nitrogen and Hydrogen.—Particularly in the chemical industry there is a demand for machines of considerable size, capable of dealing with various gases and sometimes of producing very high pressures. In such circumstances standard design has to be departed from. The firm of Peter Brotherhood, Ltd., undertakes the task of designing special machines of this character and has built compressors suitable for pressures as high as 10,000 lb. per square inch and with individual power requirements as large as 4000 B.H.P. The subject of the upper drawings on page x is a remarkable two-stage three-crank compressor. It forms the last unit of a group of machines operating upon a mixture of hydrogen and nitrogen and raising its pressure eventually to 260 atmospheres absolute. The early units of the group are of no special interest. They deliver the gas at 10 atmospheres pressure to a two-stage three-crank machine of generally similar design to that illustrated, but with cylinders of larger diameter. This intermediate machine has a suction capacity of 36,650 cubic metres per hour as measured at 20 deg. Cent. and 14·7 lb. per square inch and it runs at 120 r.p.m. It delivers the gas at a pressure of 55 atmospheres absolute to the final unit which has a measured capacity of 24,800 cubic metres per hour, runs at 120 r.p.m., and absorbs 2300 B.H.P. The general design is so well shown by the drawing that no detailed description is necessary. As a consequence of the high operating pressures the cylinders are notably small in size in relation to the dimensions of the motion work. There are three sets of two stage single-acting cylinders operating in parallel. First-stage compression occurs on the underside of the lower piston and second-stage on the upper side of the upper piston. The cylinders are supported on the totally enclosed crank case by means of eight hollow pillars and through bolts, and they are all immersed in a tank through which cooling water circulates. They are lubricated under pressure from oil ports which are so placed that they are always covered by the piston, with the result that the oil pressure tends to prevent leakage of gas. On the second stage, as shown by a detail in the drawing, the valves are spring-loaded cones, of which there are three in each unit. The massive construction is, of course, necessitated by the very high pressure. The construction of the suction valve is similar to that of the discharge valve, except for the reversed attitude of the cones. The first-stage valves, which fit into cylindrical horizontal pockets beneath the cylinder, consist of a number of spring-loaded cone valves in parallel, as shown by a detail drawing. The length of the piston-rod stuffing-box and the number of rings on the pistons bear witness to the high pressures. Metallic packings are used in the stuffing-boxes. The second box on each rod immediately above the crank case carries soft non-metallic packing and is intended principally to act as a chamber in which oil seeping down the rod can collect.

Hydrogen.—The five-stage three-crank hydrogen compressor by the same makers shown in the drawing, Fig. 26 and the photograph reproduced in Fig. 27, is also interesting. Curiously although, it might be expected that so inflammable a gas would necessitate the use of a special design, the only precautions required to be taken are those against undue leakage. The machine has a capacity of 70,700 cubic feet per twenty-four hours at one atmosphere compressed to 400 atmospheres and it runs at 250 r.p.m. All the stages, it will be observed, are single-acting and, to prevent excessive pressure should leakage past the pistons occur, the spaces beneath the first and second-stage pistons are coupled respectively to the suction side of the machine and to the second-stage suction. In general, as this compressor is made by the same manufacturers, the design is similar to that of the high-pressure machine just described. It will be noticed that the second and fourth-stage piston-rods are coupled to the first and third-stage rods in such a manner that the pistons are free to centre themselves in their respective cylinders.

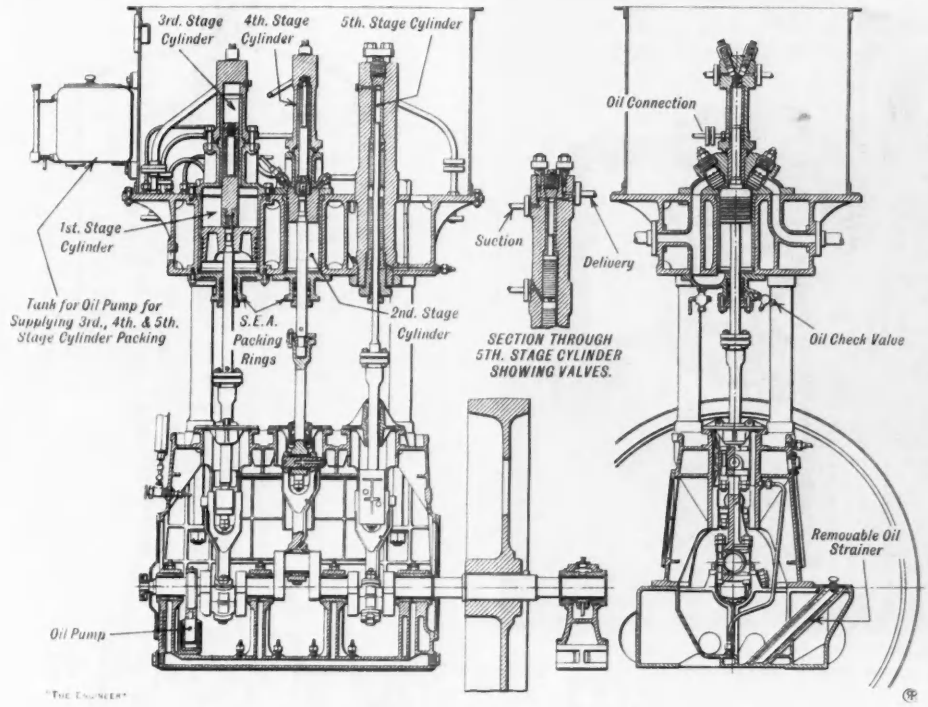


FIG. 26—FIVE-STAGE HYDROGEN COMPRESSOR—BROTHERHOOD

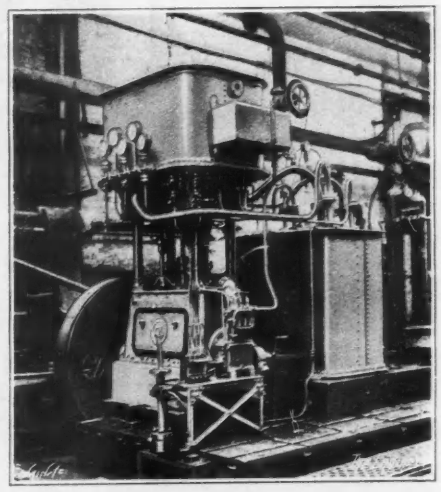


FIG. 27—HYDROGEN COMPRESSOR—BROTHERHOOD

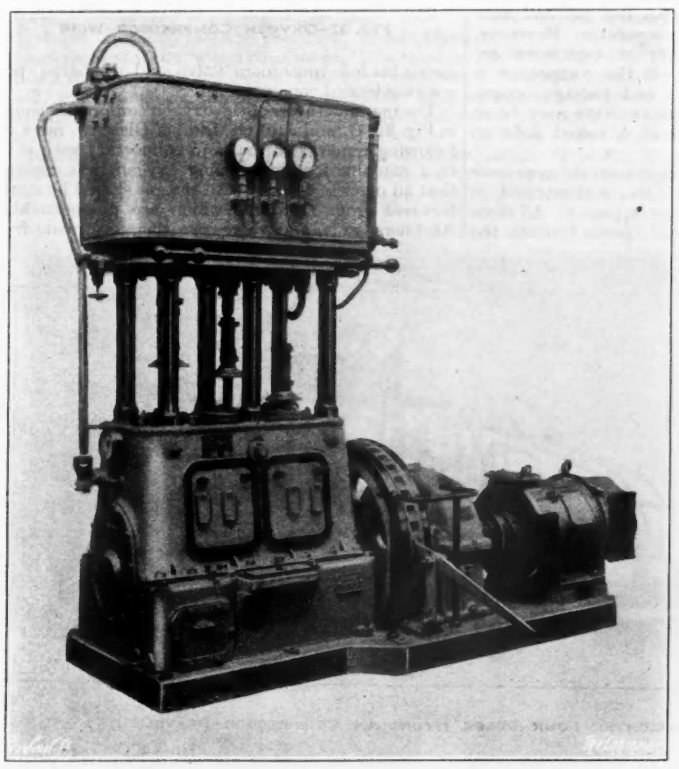


FIG. 28—OXYGEN COMPRESSOR—BROTHERHOOD

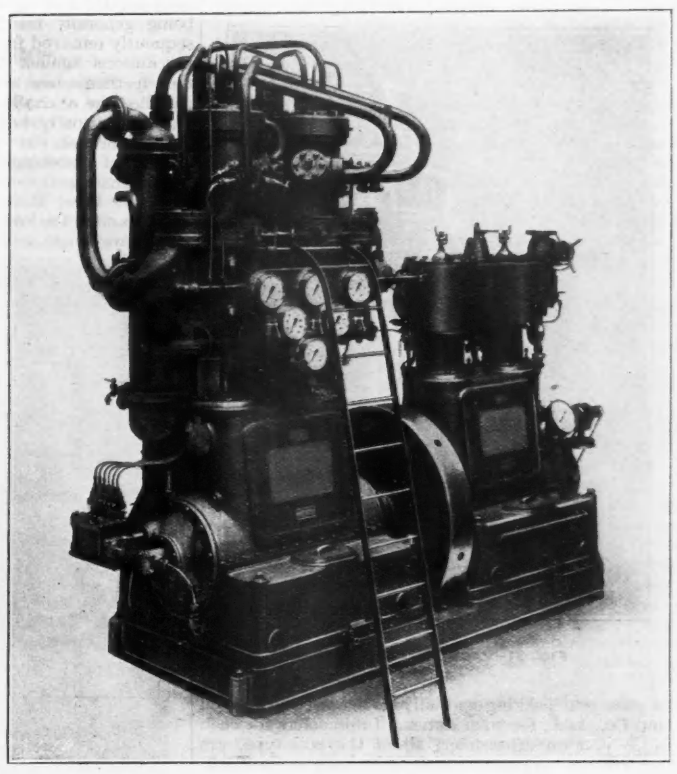


FIG. 29—HIGH PRESSURE GAS COMPRESSOR—BELLISS

C

S.E.A. piston-rod packing is used. The first and second-stage pistons are fitted with sprung-on cast iron rings; the third and fourth have cast iron carrier rings and piston rings alternately secured, to the piston rod by means of lock-nuts; and the fifth-stage piston is a plain plunger, its packing consisting of a long metallic gland with a lantern ring in the centre supplied with oil under pressure. The valves for the first four stages are of the ordinary plate type; but, the size

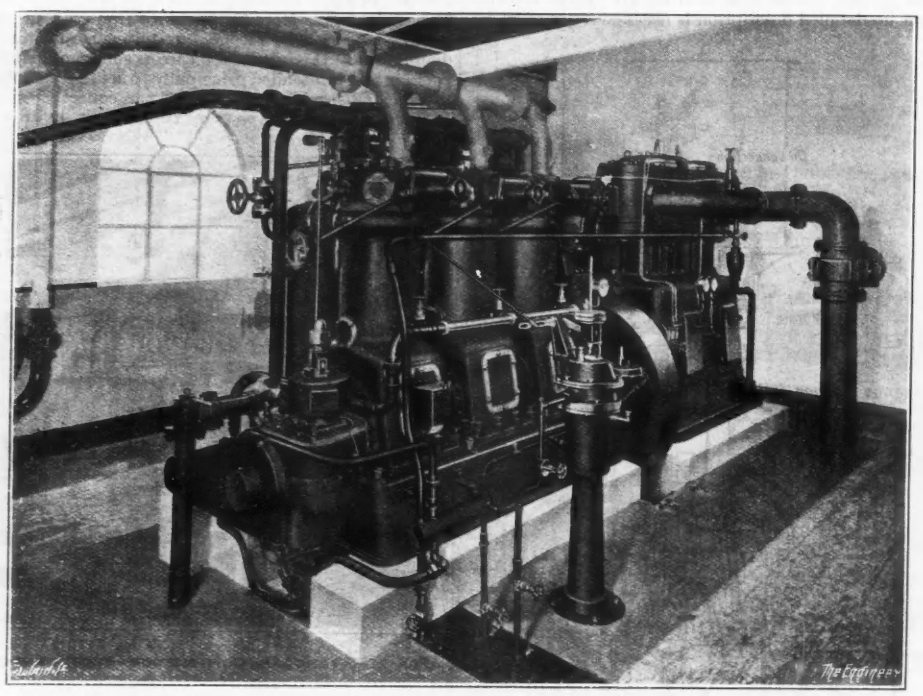


FIG. 30—GAS ENGINE-DRIVEN GAS COMPRESSOR—BRYAN DONKIN

of the fifth stage cylinder being only 1in., spring-loaded cone valves are used there.

A horizontal hydrogen compressor built by Reavell and Co., Ltd., of Ipswich, for the Fuel Research Depôt is illustrated in Fig. 33. It has a capacity of 50 cubic feet of free gas per minute compressed to 6600 lb. per square inch when running at 250 r.p.m. The first, third, and fourth stage compressions are performed on the outstroke and the second, which takes place in an annular chamber, on the instroke. Sprung-over rings are fitted to the pistons of the first two stages, but the later stages have a type

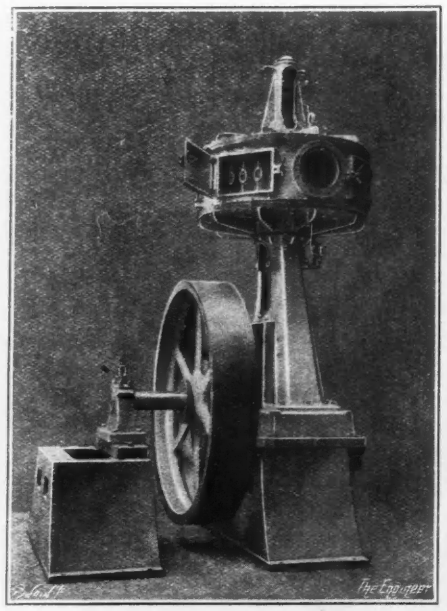


FIG. 31—VACUUM PUMP—BOBY

of cast iron packing specially developed by Reavell and Co., Ltd., for such duties. Intercoolers for each stage and an aftercooler, all of the coil type, are housed in the open top tank to be seen in the background of the photograph reproduced. The stage cooler coils are of copper, but steel is used, on account of the high pressure, for the aftercooler coil. Removable cylinder liners are fitted to the third and fourth stages, that of the fourth stage being of composite form the outer shell of which is of steel. The cover of the fourth stage cylinder is also made of steel. Ordinary low-lift plate valves are fitted to the first three stages, but for the fourth, where the diameter is very small, "thimble" type valves are used. Ring-oiled bearings support the crankshaft and sight-feed lubricators supply oil to other parts of the motion work. A mechanical force pump driven by a belt from a pulley on the end of the crankshaft supplies lubricant to the cylinders and has a separately adjustable plunger for each feed. Sight glasses allow the amount of oil passing to be observed. Owing to the high pressure that for the final stage takes the form of a pair of thick glass bulls' eyes in a metal holder.

Oxygen.—It is a remarkable fact that the gas which is most troublesome to compress is oxygen. But when the old schoolboy experiment of plunging a glowing match into a jar of oxygen and watching it burst into flames is remembered, the reason for the difficulty becomes clear. Under the high pressures and temperatures occurring within an oxygen compressor cylinder an explosion will occur in the presence even of small quantities of hydrogen, and as many oils contain hydrogen which will become free on heating, the danger is very real. Even the presence of hydrogen-free oil, if in the form of a mist, is a danger, and in consequence distilled water is used as the lubricant, being generally introduced with the gas and subsequently removed from it by a separator. Moreover, precautions against the danger of explosions are not in themselves sufficient. If the compressor is installed in a confined space and leakage occurs, materials usually not very inflammable may burst into flames at the approach of a naked light as a result of absorbing the gas.

A three-stage three-crank oxygen marine compressor made by Peter Brotherhood, Ltd., is illustrated in Fig. 28 and in the lower drawings on page x. All three stages are single-acting and the spaces beneath the first and second-stage pistons are connected with leakage valves to prevent an undue rise of pressure. Both these cylinders have stainless steel liners inserted within a gun-metal casing. Dry cotton packing is used in the piston-rod stuffing-boxes and the pistons are packed with oak bark tanned leather, as the use of metallic packing is dangerous. The third-stage piston is a 2½in. diameter plunger, whose packing consists of a gland of super grey fibre. The cylinders are all immersed in a tank of water within which are also arranged the coils of the first and second-stage intercooler pipes and the final cooler pipes. Brass baffles are fitted on the piston-rods to throw off any water that may run down them and distance pieces are inserted above the baffles, which, when removed, allow the pistons to be withdrawn without disturbing the cylinders. The machine has a capacity of 2750 cubic feet per hour and compresses to 1750 lb. per square inch. As it runs at only 150 r.p.m. plate valves are not used. Instead, as shown in the detail, suction takes place through a

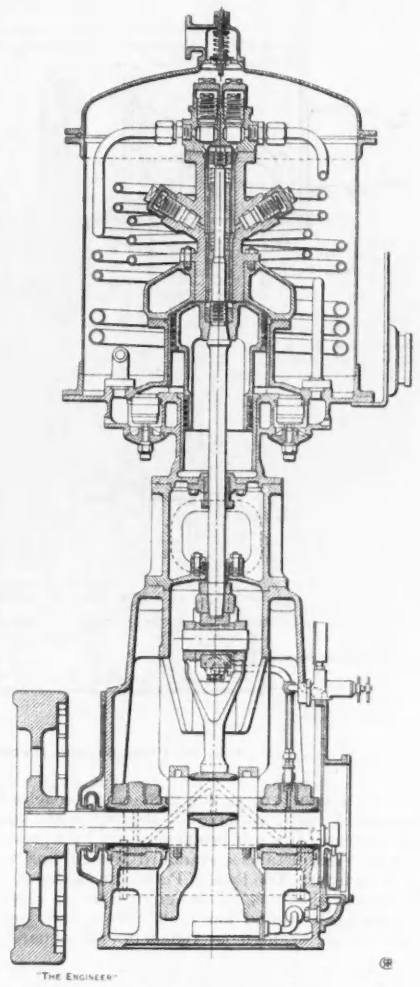


FIG. 32—OXYGEN COMPRESSOR—WEIR

spring-loaded mushroom valve and discharge past a spring-loaded cone valve.

The manufacturers of the oxygen compressor shown in Fig. 32, G. and J. Weir, Ltd., of Glasgow, have the following remarks to make in connection with it:—In a machine for compressing oxygen it is essential that all parts in contact with the gas should be manufactured from materials which are non-corrodible. All liners, rods, and valves are therefore made from Monel metal and all valve chambers and valve cages are of gun-metal. In compressing oxygen it is imperative that oil or grease should be strictly excluded from contact with the gas to prevent the danger of serious explosion. Oxygen compressors are consequently lubricated by water, and in the machine illustrated the pistons are fitted with sleeves of a special alloy and piston rings are made from a specially selected material, both of which have been found from experience to possess highly satisfactory

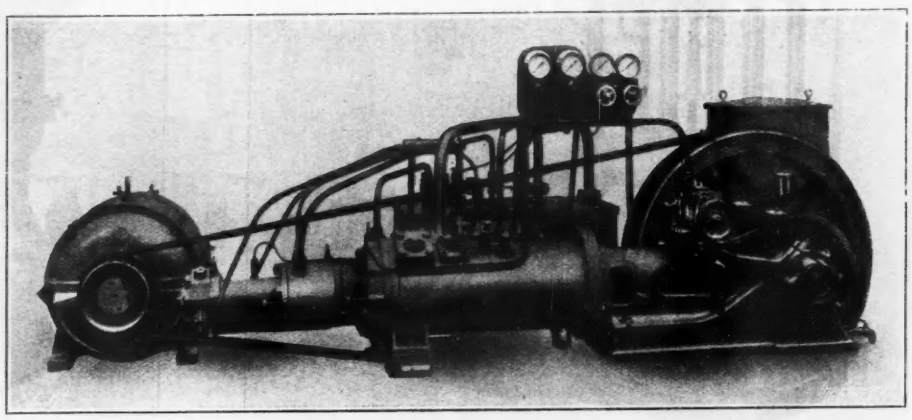


FIG. 33—HORIZONTAL FOUR-STAGE HYDROGEN COMPRESSOR—REAVELL

rubbing qualities in a cylinder lubricated by distilled water. As will be seen from the drawing, the gas cylinders are closed on the underside by a diaphragm plate and packing gland in order to prevent the escape of any gas to the crank case. The packing material used must also be entirely free from grease. The space between the piston and diaphragm plate is connected by a duct to the suction space, to prevent the building up of pressure. In an oxygen compressor the maintenance of low gas temperatures throughout the machine is even more important than in the case of an air compressor. The coolers are therefore of large sur-

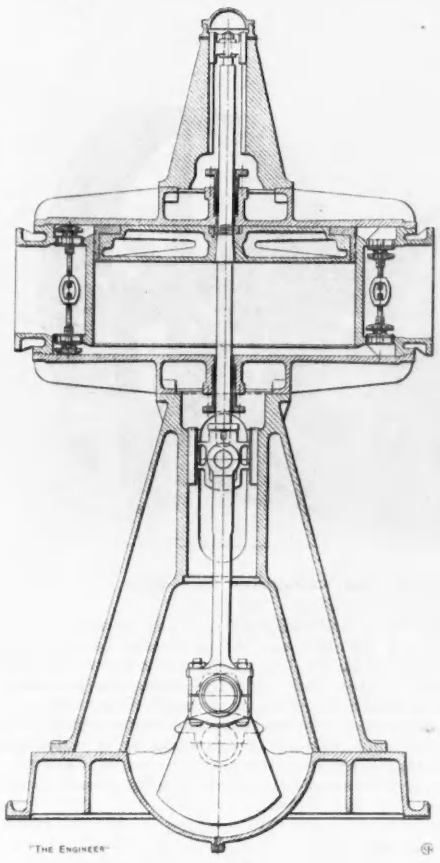


FIG. 34—VACUUM PUMP—BOBY

face area and, together with the compressor cylinders, are entirely enclosed in a common water jacket, thus ensuring uniformity of cooling water temperature for all stages, and avoiding the possibility of accidental interference with the water circulation. The machine shown is designed for a pressure of 3500 lb. per square inch, but machines suitable for considerably higher pressures are supplied by the firm to meet requirements.

Industrial Gas.—A typical example of a high-pressure compressor for industrial gas is shown in Fig. 29. It was made by Belliss and Morcom, Ltd., of Birmingham, and compresses gas in six stages to a pressure of 5000 lb. per square inch. The first and second-stage cylinders are double-acting, whilst the remaining four are single-acting. The third and fifth are mounted in tandem above the first stage and the fourth and sixth above the second. Intercoolers are, as usual, fitted between each stage. The first and second are of tubular type and the others are coils disposed in a single casing. A sight-feed lubricator driven from the end of the crankshaft is responsible for the separate lubrication of the cylinders.

A gas compressor made by the Bryan Donkin Company, Ltd., is illustrated in Fig. 30. It is driven by a three-cylinder, 93 B.H.P. gas engine at 500 r.p.m., and is designed to compress 60,000 cubic feet per hour to a pressure of 20 lb. per square inch. The control of the unit is automatic and is effected by a pressure-operated, piston-type regulator which reduces the speed of running down to a minimum of 30 per cent. of full speed, or about 150 r.p.m. by closing a throttle valve in the induction pipe of the engine in accordance with the demand for gas. The compressor itself is a two-crank, two-cylinder, double-acting machine. The firm produces gas compressors for capacities up to 300,000 cubic feet per hour against pressures up to 50 lb. per square inch at speeds varying from 300 to 600 r.p.m.

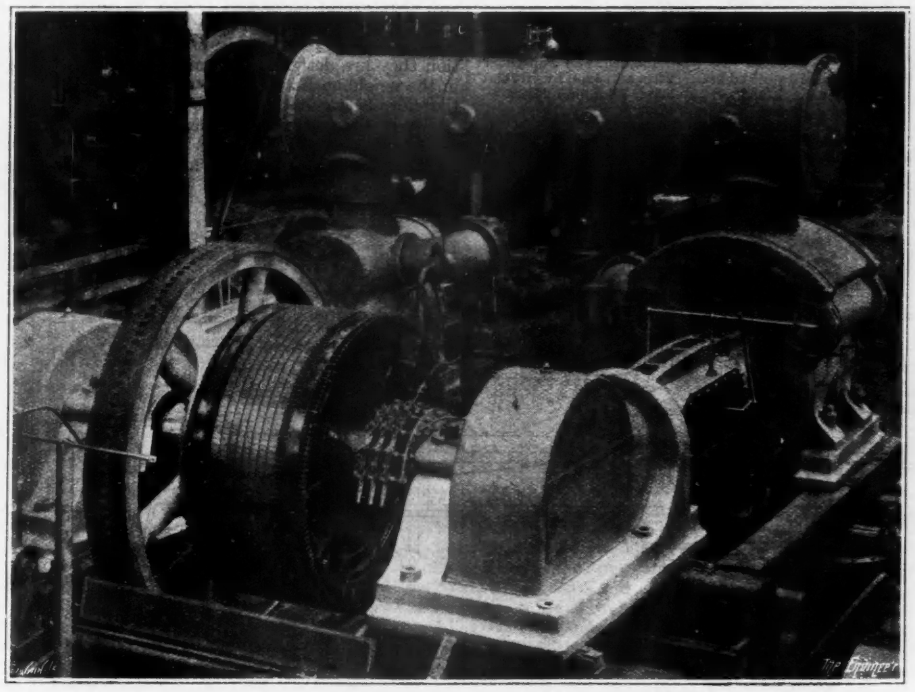


FIG. 35—MOTOR-DRIVEN AIR COMPRESSOR—WALKER

VACUUM PUMPS.

Vertical reciprocating machines are frequently used as exhausters, and we illustrate two machines as examples. The first, Fig. 36, is one made by Belliss and Morcom, Ltd., of Birmingham, the design of which, it will be observed, is very similar to that of their ordinary compressors though the cylinders are somewhat larger in relation to the dimensions of the motion work. Many other manufacturers make exhausters similar to their ordinary compressor machines. But the other machine—illustrated in Figs. 31 and 34—is made by Robert Boby, Ltd., of Bury St. Edmunds, specially for use in connection with the firm's pneumatic handling plants. The general construction will be clear from the drawing and no special reference need be made to it. The cylinder is surrounded by an annular divided chamber, wherein are fitted the valve seatings, and hinged doors allow ready access to the valves. The valve seats are interchangeable, and to each valve seat, by means of a steel stem, is attached the valve plate guard, while the steel stem also serves as a guide for centralising the valve plate on its seating. The valves consist of a non-metallic composition moulded upon a metallic core, and they are

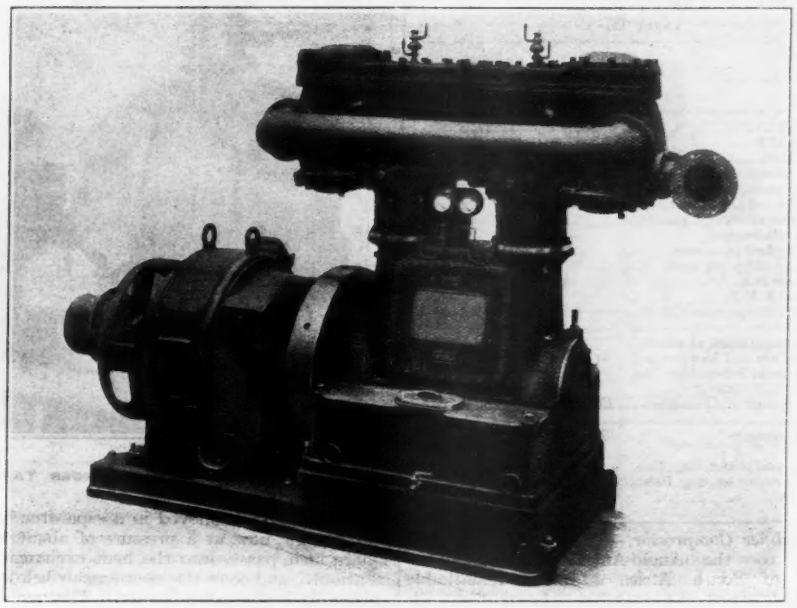


FIG. 36—TWIN-CYLINDER EXHAUSTER SET—BELLISS

reversible. Special springs are provided between the valve plate and its guard to keep the valve plate on its seating except when lifted by the action of the air.

The main piston is carried by the guides on the crosshead and tail rod and has a definite clearance from the cylinder walls. The arrangement is advantageous as far as wear is concerned and does not, it is said, interfere appreciably with efficiency. Top and bottom glands have gun-metal neck rings and gland bushes and graphite impregnated packing is used. The speed of running is low, only 150 r.p.m., and in consequence the makers claim that the machines give long life. Forced lubrication is effected through a suitable multi-way pump fixed on the pump column, driven from the crankshaft. Larger units are made by duplicating or trebling the number of units and mounting on a single bed-plate. A twin unit recently supplied to the Port of Leith has cylinders 51in. diameter and 20in. stroke. It is driven by a 260 H.P. motor through totally enclosed double-helical reduction gearing.

HORIZONTAL MACHINES.

Horizontal machines appear to be more popular abroad than in this country, for the number of manufacturers here appears more limited than that of those producing vertical and other types. Numerous machines of the kind will, however, be found described in the Continental and American sections of this Supplement. For very large volumes the horizontal arrangement has some special advantages, notably in the reduction of headroom required, as compared to a corresponding vertical arrangement and by the spreading of the load over the foundations. Since machines of this character usually run at slower speeds cooling within the cylinder can more effectually be carried out with a consequent increase in efficiency. Smaller horizontal machines find uses particularly in work such as mining and tunnelling, where headroom is limited, or where temporary buildings require to be erected to house them, as in contractors' work, and on shipboard when they are to be installed in "'tweendecks."

Among makers of horizontal machines in this country, Walker Brothers (Wigan), Ltd., specialise particularly in the supply of compressors to collieries and mines, and have manufactured some very large machines driven both by steam and electrically. The engraving, Fig. 35, shows a typical electrical unit of 5000 cubic feet capacity supplied recently to the Nundydroog gold mines in India. It is a two-stage machine with two cranks and by mounting the intercooler transversely above the compressor cylinders, a particularly neat and efficient arrangement is attained, since there are no air pipes to and from the intercooler as there must be with vertical machines. The rotor of the driving motor is mounted on the crank-

shaft alongside the fly-wheel. In order that it shall be possible to remove the rotor if and when repairs become necessary without removing a crank, it is carried by a spider on the fly-wheel and is of sufficient internal diameter to pass over the crank.

Machines of this design achieve a high efficiency. In an accompanying drawing, Fig. 37, there are reproduced to one-half full scale precisely indicator cards from the cylinders of a 5000 cubic foot machine designed to operate at an elevation 1100ft. above sea level. The details of the test are given in Table II. The test was conducted after only 6 hours' running on full load, so that the metallic packings cannot be expected to have properly bedded down, and the air valves were no doubt still leaking. The pipes from the compressor to the air receiver and nozzle were about 100 yards long. The cylinders of the machine were 18in. and 30in. diameter, the stroke 22in., and the speed 180 r.p.m.

TABLE II.

	From nozzle.	From indicator cards.
Free air output, c.f.m.	2529	2750
Indicated A.H.P.		435·45
Isothermal H.P.	310·56	337·7
Isothermal efficiencies:		
Combined plant, per cent.	60·9	66·3
Compressor only, per cent.	66·22	72
Compression efficiency, per cent.	71·3	77·6
Mechanical efficiency:		
Combined plant, per cent.		85·4
Compressor only, per cent.		92·8
Cubic feet per B.H.P.	5·392	5·86
Power input, E.H.P.	509·8	
Power input, compressor B.H.P.	469·0	
W.G. and temperature at nozzle	15in.	97 deg. Fah.
Air temperature and barometer	64 deg. Fah.	29·58in.
Air to and from intercooler, deg. Fah.	256	83
Final temperature and pressure	232 deg. Fah.	90 lb. per sq. in.
Intercooler pressure	28·5 lb. per sq. in.	
Jacket inlet and outlet, deg. Fah.	54·5	62
Cooler inlet and outlet, deg. Fah.	54·5	70
Water, g.p.m.	80	

Dehumidifier Compressor.—These makers recently supplied to the Anglo-American Mining Corporation of South Africa a rather remarkable machine designed to supply dehumidified air to pneumatic tools operating in a deep mine on the Witwatersrand. The temperature in South African mines is no higher than in the coal mines in this country, but in order to keep down dust and so avoid miners' disease, it is necessary there to water the passages and a warm humid atmosphere difficult to work in is created. How to ameliorate these conditions throughout the whole of the mine workings is a problem that has not yet been solved. But conditions at the working faces can be much improved by making use of the cold exhaust from pneumatic tools. In order further to enhance the effect the air supplied to the tools can be dehumidified so that cold dry air is exhausted from the tools to mix with the warm humid air already present.

The machine, a plan of which is reproduced in Fig. 40, has two cranks. On one line there are in tandem from the crank the L.P. steam, first-stage air and third-stage air cylinders, and on the other the H.P. steam, second-stage air and an air re-expansion cylinder. The air is compressed in three stages to about 130 lb. per square inch pressure, being intercooled after each stage. It then passes to an aftercooler, and thence through a heat exchanger, the function of which will be made clear later, to the re-expansion cylinder. There it is re-expanded, returning energy to the machine. The cut-off is so regulated by an automatic thermostatic gear that the final temperature never falls below 32 deg. Fah., a limit imposed to prevent the formation of snow. Water is, of course, condensed out by this expansion and is removed in a separator before the cold dry air, now at a pressure of about 90 lb. per square inch, passes into the heat exchanger already mentioned, and cools the incoming air below the level attainable in the after cooler. The air is finally delivered to the receivers in the mine at a temperature of about 80 deg. Fah. In order to effect this dehumidification, rather less than 10 per cent. more power is required, as compared with a normal machine. But the makers state that 54 cubic feet of dehumidified air will perform as much useful work as 100 cubic feet of normal compressed air, owing to the fact that it can be expanded further without troubles arising owing to condensation and the formation of "snow." On balance therefore a considerable saving is shown.

The following table gives some particulars of the plant:—

Capacity	10,000 c.f.m. and 80 lb. per sq. in.
Steam conditions	200 lb. per sq. in. and 100 deg. Fah. superheat
Steam cylinders and stroke	25in. and 52in. by 4ft. 6in.
Air cylinders	53in., 35in., and 24¼in.
Expansion cylinder	17in.
Speed	84 r.p.m.
Piston speed	756ft. per minute
Overall dimensions	76ft. 6in., 21ft. 6in., 13ft. 9in.
Total weight	250 tons

An interesting point in the design is that, as usual, the piston-rods are cambered to relieve the cylinders of the weights of the pistons, thus reducing wear and friction. All the iron used in the castings was refined by the soda ash process developed by Imperial Chemical Industries, Ltd.

Compressor and Vacuum Pump.—The machine shown in Fig. 39 is a combined low-pressure compressor and vacuum pump, made by G. and J. Weir, Ltd., of Glasgow, such as is now largely used for the operation of pneumatic conveyors in business premises. The machine is of the two-cylinder tandem type, both cylinders being double-acting. One cylinder operates as a compressor, while the other acts as a vacuum pump, the action of each being entirely independent of the other. An automatic governor is fitted on each cylinder to limit the pressure and vacuum in the receiver to the desired values.

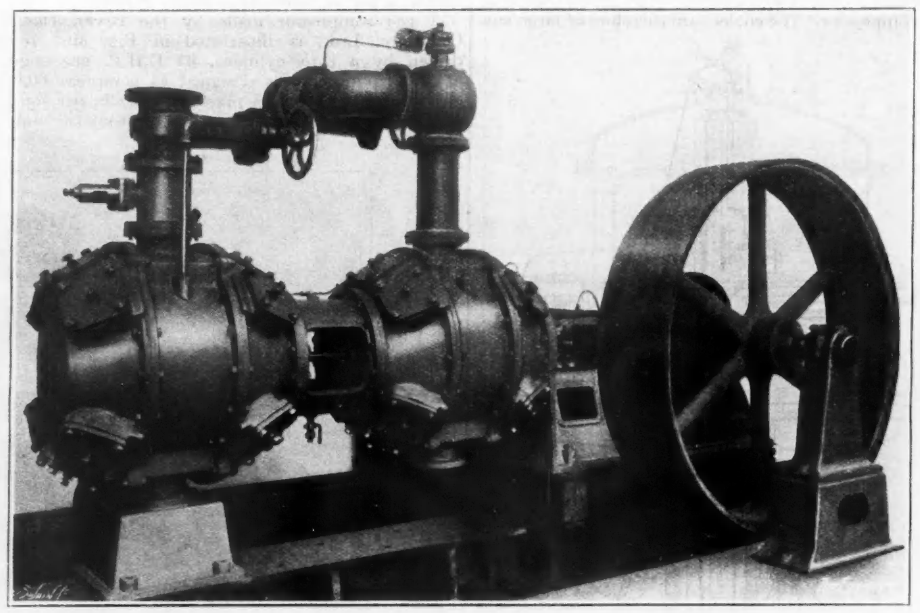


FIG. 39—TWO-CYLINDER TANDEM COMPRESSOR AND EXHAUSTER SET—WEIR

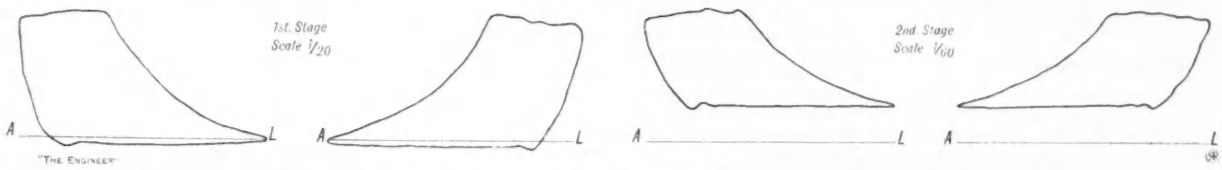


FIG. 37—INDICATOR DIAGRAMS FOR 5000 CUBIC FEET COMPRESSOR—WALKER

Several sets of these machines have been supplied, and in each the cylinders were interconnected in such a way that both cylinders could be switched on to either pressure or vacuum at will. This arrangement allows of increased flexibility in the relative pressure and vacuum capacities of the installation. These machines cover a range of capacities up to 1000 cubic feet per minute displacement per cylinder, and they are of horizontal design, in order to allow of their being installed in low ceiling compartments, such as basements. Being of long stroke construction they are designed for comparatively low speeds in the neighbourhood of 150 to 200 r.p.m. They are therefore best suited for drive by belt.

Vis-à-Vis Machines.—Mention was made at the beginning of this section of contractors' air compressing plant. In many cases this plant has to be installed in places remote from

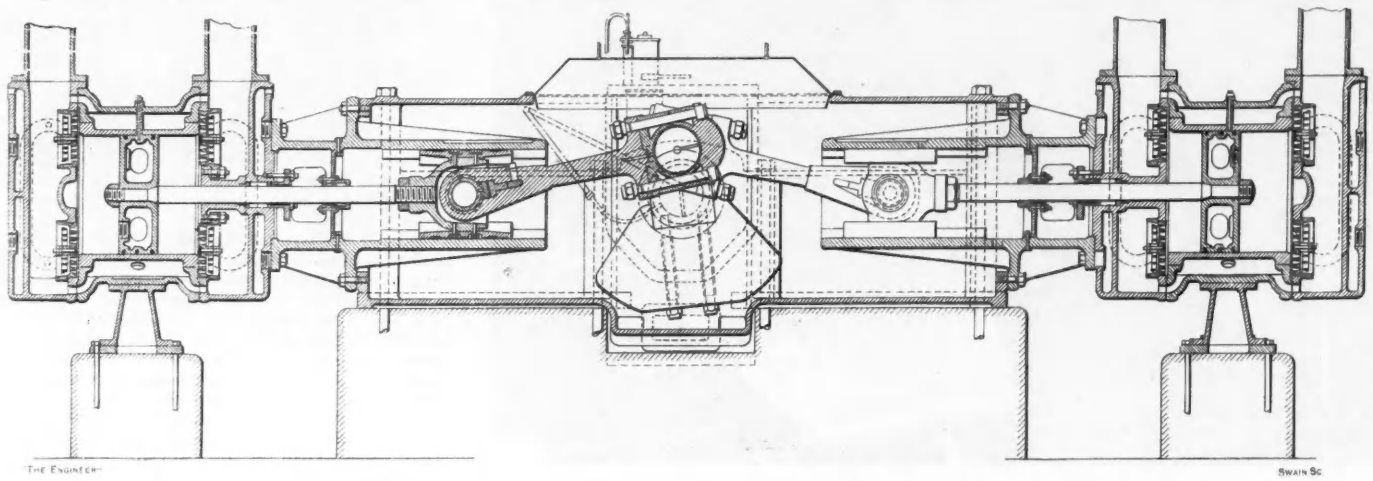


FIG. 38—2000 CUBIC FEET CAPACITY VIS-A-VIS COMPRESSOR—ROBEY

sources of electrical energy, and in such circumstances an oil engine drive is particularly convenient, whilst a horizontal vis-à-vis arrangement allows the plant to be installed in a low-roofed temporary building. Recently, in THE ENGINEER, a very full description was published of a plant of this character supplied to the contractors for the Dartford–Purfleet tunnel, Charles Brand and Son, Ltd., by Robey and Co., Ltd., of Lincoln, and a section through one of the vis-à-vis compressors of 2000 cubic feet capacity, delivered against 50 lb. per square inch, is reproduced from that article in Fig. 38. The firm also constructs

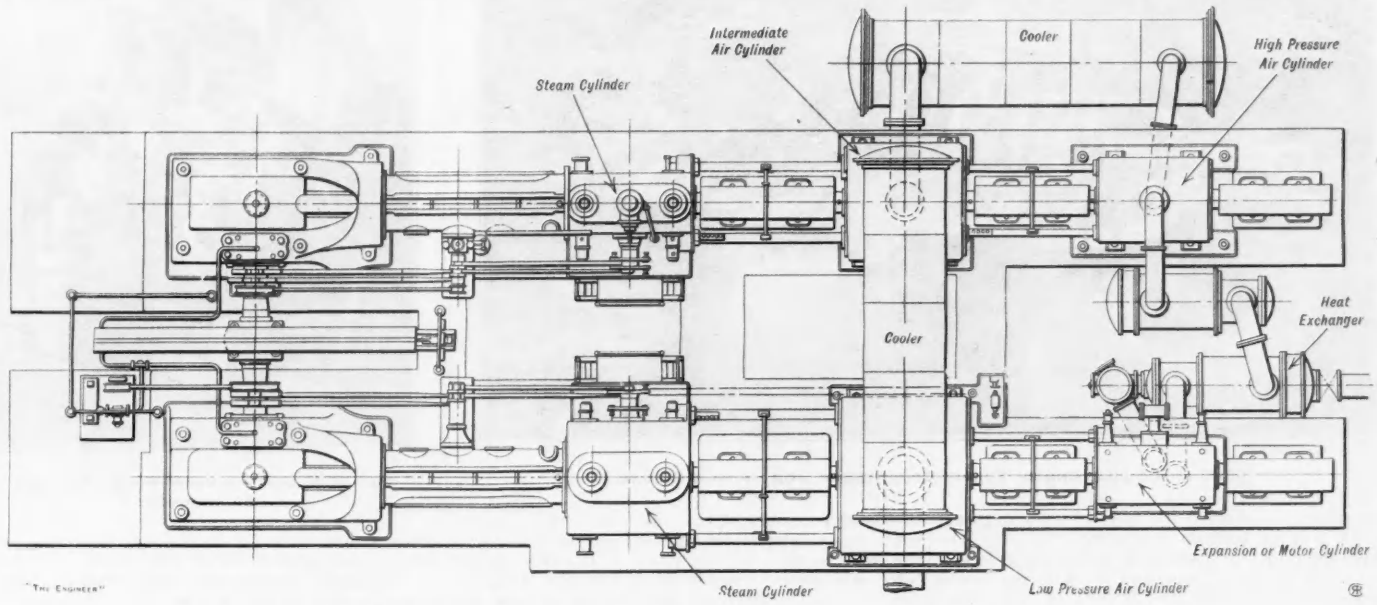


FIG. 40—THREE-STAGE STEAM-DRIVEN TWO-CRANK DEHUMIDIFIER AIR COMPRESSOR—WALKER

oil engine-compressor vis-à-vis sets, and ordinary horizontal compressors. The vis-à-vis oil engine compressor unit illustrated in Fig. 42 is made by Crossley Premier Engines, Ltd., of Sandiacre, in conjunction with Reavell and Co., Ltd., of Ipswich, who supply the compressor end. A typical set consists of a two-cylinder oil engine vis-à-vis to a two-stage compressor, with an intercooler arranged transversely. It has a capacity of 750 cubic feet per minute delivered against 100 lb. per square inch, and various particulars are given for this size of machine in the following table:—

Bore of power cylinders, inches	15
Piston stroke, inches	23
Revolutions per minute	230
Power output, B.H.P.	160
Air cylinders, inches	19¼ and 11¾

Machines of this kind are built with capacities up to 3500 cubic feet per minute.

TURBO-BLOWERS AND COMPRESSORS.

When large quantities of air or gas are to be compressed to comparatively low pressures the turbo machine has many advantages to offer. While the dimensions of a reciprocating machine become swollen

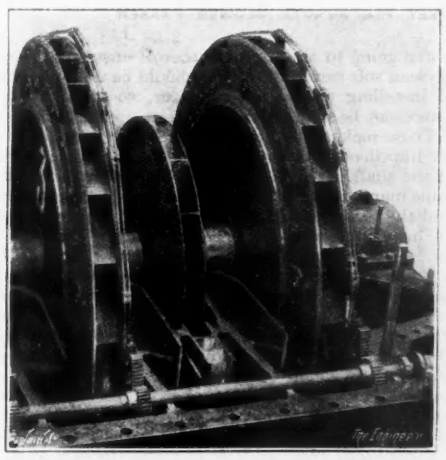


FIG. 41—ADJUSTABLE GUIDE VANES—RICHARDSONS

to large proportions to accommodate the quantity of gas, the turbo-blower running at a high speed occupies considerably less space, and is lighter, so that foundation design is simpler. Though its efficiency may be less, the simplicity of the turbo machine is likely to lead to smaller maintenance costs. It has no delicate valves to break or give trouble, rubbing surfaces are confined to journal and thrust bearings, which can comfortably be made of ample size to carry the loads which fall upon them, and the accessibility is such that the mere lifting of the top cover, without disturbing any pipe joints reveals all parts for inspection. Since this kind of machine first began to be developed, it has challenged the reciprocator in fields of higher and higher pressure, and for smaller and smaller deliveries. Pressures as high as 150 lb. per square inch are now reached in single casing machines, and deliveries as low as 2000 cubic feet per minute can be efficiently dealt with. Turbo machines have an additional advantage for certain processes that the air or gas is delivered in a steady scarcely varying stream, and their speeds of running are such that they are well adapted to be driven by steam turbines. To-day they find many uses, particularly for supplying air to blast and other large furnaces, for the aeration of sewage, for the compression of large volumes of gas in chemical works, and as exhausters.

The principle of operation of turbo machines is well known, and is identical with that employed in centrifugal pumps. The gas is drawn into the eye of an impeller and flung outwards centrifugally into some form of diffusing chamber which converts its kinetic into pressure energy. It is then either discharged from the machine or fed through guide vanes into another impeller on the same shaft for further compression. But beyond the principle of the action, similarity with the centrifugal pump ends. As a result of the compression, the gas occupies a smaller volume, so that the width of the blades in successive impellers becomes less, and sometimes the diameter also is reduced, as shown by the drawing of a Hick, Hargreaves machine, Fig. 55. The gas also becomes heated and as a result of the consequent expansion each stage has to work upon a greater volume of gas than would be necessary were it not heated. In blowers with small compression ratios this effect may not be serious, but for higher discharge pressures it is necessary to make provision for cooling. Two methods are adopted. Some makers—C. A. Parsons and Co., Ltd., for example—cause the gas to be circulated through an intercooler after every third stage of compression. The intercoolers are usually situated beneath the blower proper so that the connecting passageways are short. This arrangement gives efficient cooling, but requires the gas to be removed from and returned to the casing with a small resulting loss. It is used particularly in large machines. Alternatively, other makers—such as Daniel Adamson and Co., Ltd.—water jacket the casing and so cool the gas at every stage. This arrangement has the disadvantages that if dirty or hard water has to be used, the jackets will have to be regularly cleaned, and it is difficult to make provision for adequate cleaning doors. In addition the castings for the casings are complicated by the presence of the jackets. The firm mentioned has developed a special design, which is claimed to give particularly efficient cooling and the difficulty resulting from the use of dirty water is overcome by arranging for a heat interchanger and circulating only distilled water through the jackets.

Sometimes when a machine is to be used against variable discharge pressures the guide vanes are so mounted that their angular relation to the impellers can be altered. By this means a high efficiency can be held over a considerable range of output and pressure. One end of each blade is pinned to a stationary member held in the casing, while the other end is pinned to a ring that can be rotated by external means. A typical example of the type of construction that may be adopted is shown in Fig. 41. This arrangement is that adopted in machines made by Richardsons, Westgarth-Brown, Boveri, Ltd., a firm whose products are more fully dealt with in the Continental section of this Supplement.

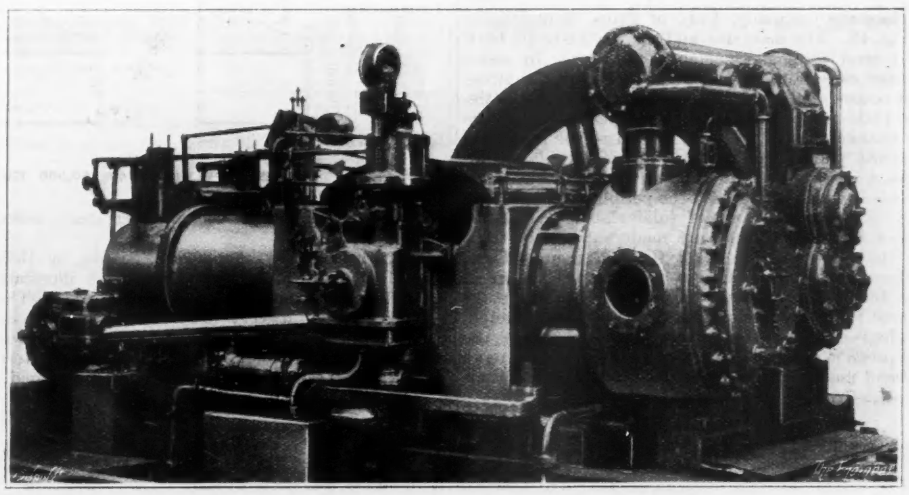


FIG. 42—VIS-A-VIS TWO-STAGE OIL ENGINE COMPRESSOR SET—CROSSLEY-REAVELL

Three machines in which this movable diffuser mechanism is fitted are installed at the Corby works of Stewarts and Lloyds, Ltd., for the service of blast-furnace plant. They are claimed to be the largest machines of their kind in Europe and have an output of 50,000 cubic feet of free air per minute at 30 lb. per square inch. They run at 3600 r.p.m. One of them is illustrated in Fig. 46.

In one matter of operation there is a relation between turbo compressors and centrifugal pumps. Some years ago a number of pump manufacturers were troubled by a "break" in the well-known centrifugal pump characteristic curve at constant speed, which resulted in unstable delivery with a violent fluctuation of discharge pressure and delivery volume. The same "break" is found in the similar characteristic of the turbo-blower and compressor, but it occurs at much higher deliveries, between

75 and 50 per cent. of the normal output, and makes it impossible to reduce the output below a critical value, known usually as the pumping limit. The governing and control gear has to be designed to take this factor into account, and the usual arrangement is one whereby the machine is unloaded as the pumping volume is approached.

A typical turbo-blower, now building for customers in India at the works of C. A. Parsons and Co., Ltd., of Newcastle-on-Tyne, is illustrated by the drawing, Fig. 44, and the half-tone engraving, Fig. 43. The normal duty of this machine is 40,000 cubic feet of free air per minute, compressed to 14 lb. per square inch gauge, when the speed is 3450 r.p.m. By raising the speed to 3650 r.p.m., the same quantity is compressed to 18 lb. per square inch. As can be seen from the engravings, the machine is of the double inlet type, with four runners per side, and it is provided with diffuser blades for the conversion of the kinetic energy of the air. The construction is in most respects that usually adopted by those makers. Each impeller consists of two discs made from high-tensile steel forgings between which the vanes are riveted. The impellers are balanced individually before assembly and the complete shaft with its impellers in position is subsequently balanced dynamically. In single-ended machines, the shaft is located in its correct position relative to the diffuser blades by a pivoted pad thrust block, whilst the end thrust is principally taken by a dummy piston with labyrinth packing in a manner very similar to that adopted for turbines. The casing is built up of a number of sections bolted together.

The design of impellers for a 50,000 cubic foot per minute blower, made by Fraser and Chalmers Engineering Company, Ltd., of Erith, is illustrated in Fig. 45. The main disc and the side plate are both solid steel forgings, machined all over. In order to take care of the somewhat high tangential stress that occurs at the hub, it is usually necessary for the side plate to be made of an alloy steel. The blades are channel shaped, and are riveted to the main disc and side plate. For medium duties the blades are pressed into shape from alloy steel sheets, but when the blade width is large and the peripheral speed high, they are machined out of solid slabs. When the blades are narrow, they are made sufficiently thick for the rivets to pass right through them. These makers build up casings in the manner shown in Fig. 48, which represents the design of a four-stage blower. The absence of diffuser blades will be noted. Blading is practically always necessary when the compression ratio is high and always results in a more efficient machine. But when the operating conditions are likely to be variable, unbladed diffusers have the advantage that the machine retains a high efficiency over a wide volumetric range. The axial thrust in single-ended machines is partly cared for by a balancing piston and partly carried by a Michell or a multi-collar bearing. This arrangement brings about a reduction in the diameter of the balance piston and thereby reduces leakage losses. At the sealing surface of the balance piston the bore and the outer periphery of the rotor are both machined with closely pitched circumferential fins, cut out of the solid metal. As the pitch of the fins on the rotor and stator respectively is slightly different, only about one-tenth of the number of fins are situated directly opposite each other. Normally, labyrinth end packings are used, but hydraulic packings are more suitable when complete gas-tightness is required, and in certain cases steam sealing can be employed.

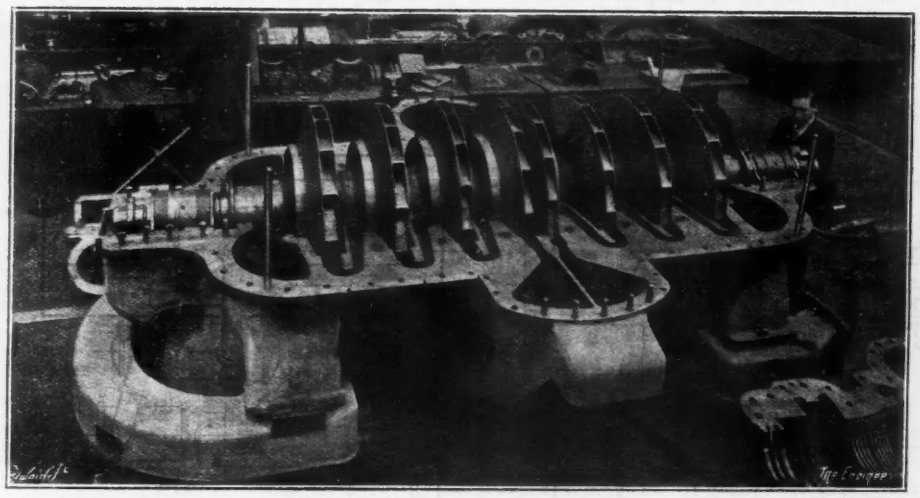


FIG. 43—DOUBLE-ENDED TURBO-COMPRESSOR FOR INDIA—PARSONS

The arrangements adopted for cooling by Belliss and Morcom, Ltd., of Birmingham, are illustrated, somewhat diagrammatically, in Fig. 47. These makers consider it very desirable (as, indeed, it is on theoretical grounds) that cooling should occur continuously, and not intermittently in external coolers. Water passages are therefore formed in the casing. Each cell is cooled independently. The water enters at a bottom manifold and comes out at a top one and thence down the passages of the outlet casting to a branch at the bottom. In addition to circulating the water in the areas A, which is effected without difficulty, these makers provide a number of wedge-shaped passages streamlined externally, so as not to interfere with the air flow, which carry water to the spaces B alongside the diffusers. Further cooling is effected by fins C above the diffusers. The wedge-shaped passages provide for cleaning when necessary. The makers consider that the advantages of internal cooling on this plan are such that it is worth going to the trouble either of ensuring the use of clean soft water, or, if that should be unobtainable, of installing a heat interchanger, so that distilled water can be circulated.

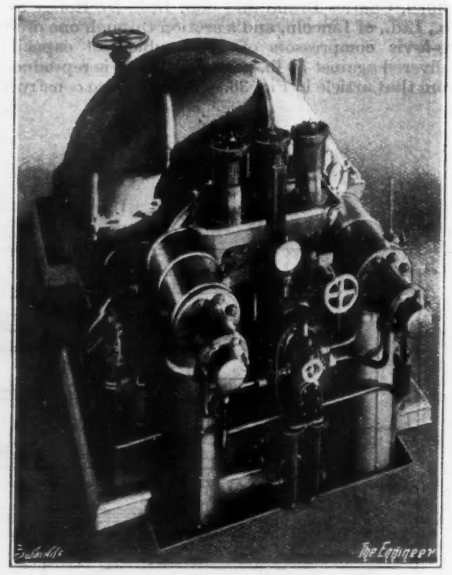


FIG. 46—BLAST FURNACE TURBO-BLOWER —RICHARDSONS

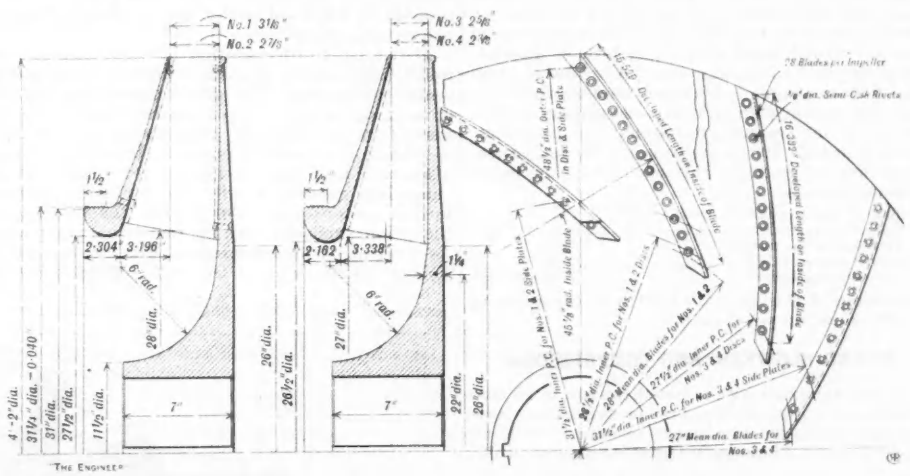

No.1 3⅛"
No.2 2⅞"
No.3 2⅝"
No.4 2⅜"
1½"
2·304" 3·196"
6" rad.
28" dia.
7"
4'-2" dia.
31½" dia. – 0·040"
31" dia.
27½" dia.
11½" dia.
1½"
2·162" 3·338"
6" rad.
27" dia.
26" dia.
26½" dia.
7"
1¼
22" dia.
26" dia.
78 Blades per Impeller
⅝" dia. Semi C.sk Rivets
16·259" Developed Length of Inside of Blade
16·332" Developed Length of Inside of Blade
40⅞" dia. Outer P.C. for Nos. 1 & 2 Discs & Side Plates
40⅞" dia. Inside Blade Plates
31½" dia. Inner P.C. for Nos. 1 & 2 Side Plates
29⅝" dia. Inner P.C. for Nos. 1 & 2 Discs
26" Mean dia. Blades for Nos. 1 & 2
27½" dia. Inner P.C. for Nos. 3 & 4 Discs
31½" dia. Inner P.C. for Nos. 3 & 4 Side Plates
27" Mean dia. Blades for Nos. 3 & 4
THE ENGINEER

FIG. 45—IMPELLERS FOR 50,000 CUBIC FEET PER MINUTE BLOWER—FRASER

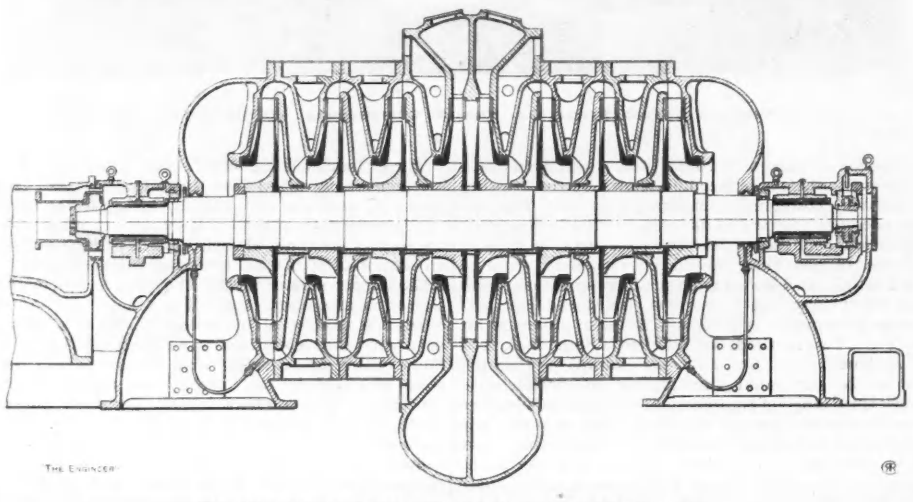


FIG. 44—DOUBLE-ENDED TURBO-COMPRESSOR—PARSONS

These makers use chrome-nickel-molybdenum steel for impellers, which are carried on spigot rings clear of the shaft. The distance sleeves are carried in the same manner. Impeller blades are made of duralumin and the rivets pass right through them, so that there are no flanges or rivet heads to disturb the flow of air. Unbalanced thrust is taken almost entirely by a dummy piston, plain collars at the coupling end bearing taking the remainder and locating the shaft.

The turbo-compressor illustrated by the drawing, Fig. 55, is typical of the design adopted by Hick, Hargreaves and Co., Ltd. It is a twelve-stage machine, of which only six stages are shown. The casing is formed of a number of sections bolted together, and the cooling jackets formed in the casing are so designed that the chambers are easily accessible for cleaning. In order to prevent foreign matter collecting in the jackets, the cooling system is so arranged that the water flow can be reversed. A machine of the type illustrated will give a performance such as that shown by the following figures :—

Normal suction quantity at atmospheric pressure	10,000 c.f.m.
Range of output	12,000 to 4,000 c.f.m.
Discharge pressure	100 lb. per sq. in. gauge
Speed range	4,600 to 5,500 r.p.m.
Cooling water	650 g.p.m.

In the construction of rotors Reavell and Co., Ltd. and the Metropolitan-Vickers Electrical Company, Ltd., utilise a system different from any yet mentioned. The impellers are built up as usual from high-tensile steel forged hub discs, and cover plates. But the

rivets which hold the vanes in position are formed integrally with the vanes themselves. In the Reavell design nickel-chrome steel is used, and the blades are bent to the required form and trepanned. The shaft is of nickel or Siemens-Martin steel, and the impellers are keyed on to it.

The design of a very large gas blower now going through the Ipswich shops of Reavell and Co., Ltd., is illustrated in Fig. 49. Four machines of this design, driven by Allen turbines, are to be supplied to the Beckton gasworks for gas boosting. Each machine is of the single-flow type, with three stages, and is capable of handling 2,000,000 cubic feet of gas

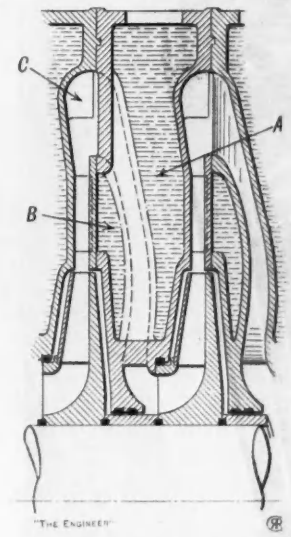


FIG. 47—COOLING ARRANGEMENT—BELLISS

per hour, with a normal pressure rise of 150in. of water gauge and maximum rise of 165in. The specific gravity of the gas varies between 0·4 and 0·5. The normal speed of the units is 3900 r.p.m., and they are to be simultaneously controlled by a bell regulator through a system of shafts and links to maintain the delivery pressure constant at any value between the limits of 20in. and 165in. In addition, two of the machines are to have independent gas pressure regulation. The casing, it will be observed from the drawing, is a single casting with the end pieces and it is of interest to note that despite the low pressures to which it will be subjected in service, each casing is water tested to 50 lb. per square inch to ensure that there is no porosity, and therefore no leakage of gas. There are labyrinth packings at each end of the machine with provision for oil sealing, and the balance piston also has labyrinth packing. The machines are claimed to be the largest of their kind in Europe. The diameter of the runner is about 43in. The shaft is designed so that the maximum running speed shall be below the first critical.

A number of photographs are reproduced on page xviii, showing examples of turbo machines made by various manufacturers. The four-stage single-flow blast furnace blower by Fraser and Chalmers Engineering Company, Ltd.—Fig. 54—was installed to deliver air to a series of small furnaces, and is regulated at present to maintain a constant delivery pressure. At a later date it is to be used in connection with a single large furnace, and will then be regulated to give a constant volume. On test, according to figures given to us by the makers, this blower gave the performance recorded in Table III. The pumping limit at 10 lb. per square inch delivery pressure occurred at 9000 cubic feet per minute. It will be seen that the maximum volume at this pressure is about five times as great and that the efficiency is well maintained. This result is to be attributed to the absence of diffuser blades, and is the kind of performance that is required where several furnaces are to be served by a single blower. The figures may be compared with those in Table IV, which refer to a blower used for the aeration of sewage. In work of that character the operating conditions remain constant over long periods, and high efficiency is essential. Diffuser blades are therefore used. The blower concerned, which is driven by a sewage gas engine through speed-increasing gear, has a pumping limit of about 7500 cubic feet per minute and a maximum output, limited by the engine power, of 15,000 cubic feet per minute.

TABLE III.

Duration of test, minutes	60	60	60	60
Barometer, in. Hg. ...	29·91	29·90	29·80	29·80
Delivery pressure, in. Hg.	24·25	32·65	20·71	20·96
Inlet temperature, deg. Fah.	73·7	76·5	76·4	76·1
Outlet temperature, deg. Fah.	204·7	250·0	192·0	205·1
Air volume,* c.f.m. ...	30,350	30,680	31,055	42,870
Overall efficiency,† per cent.	75·4	72·9	75·4	68·6

TABLE IV.

Duration of test, minutes	60	60	60
Barometer, in. Hg.	30·68	30·68	30·68
Delivery pressure, in. Hg.	14·40	14·68	18·39
Inlet temperature, deg. Fah. ...	53·2	52·4	55·5
Outlet temperature, deg. Fah. ...	130·3	131·2	151·5
Air volume,* c.f.m.	10,000	12,740	10,500
Overall efficiency,† per cent. ...	77	77·3	76·9

* Referred to inlet conditions.
† Referred to adiabatic compression.

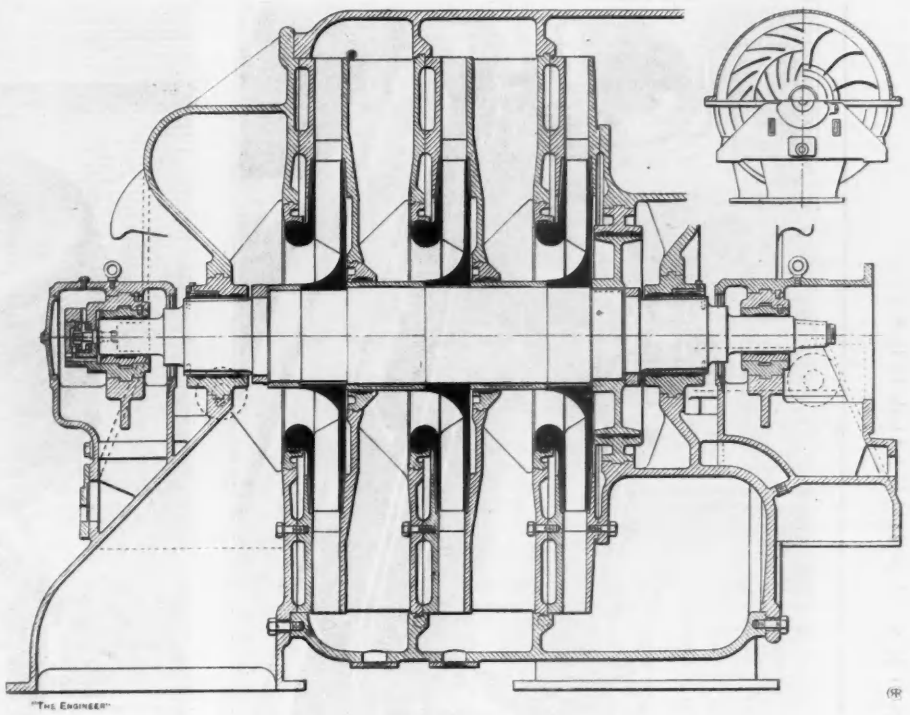


FIG. 49—THREE-STAGE 2,000,000 CUBIC FEET PER HOUR GAS BLOWER—REAVELL

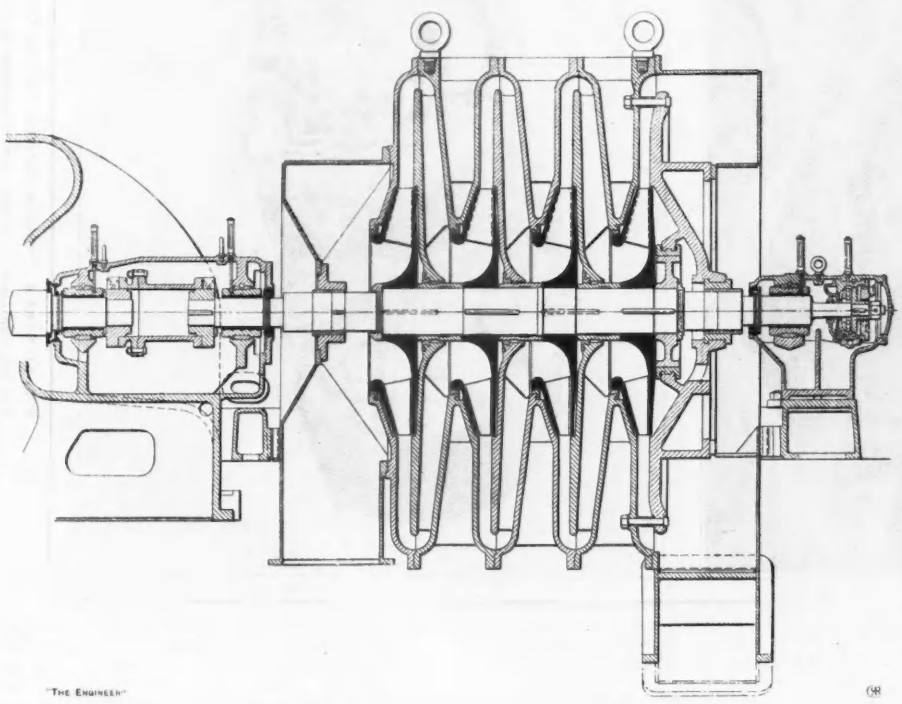


FIG. 48—FOUR-STAGE BLOWER—FRASER

A machine by Hick, Hargreaves and Co., Ltd., of Bolton, is illustrated in Fig. 53 on page xviii. It has a normal capacity of 17,500 cubic feet per minute of free air delivered against a pressure of 80 lb. per square inch gauge, and has been installed in a Lancashire colliery for supplying air to tools and machinery below ground. It is direct-coupled to a mixed pressure steam turbine, with a rating of 3230 H.P., when running at 3800 r.p.m.

Another engraving on the same page, Fig. 52, shows a machine made by Belliss and Morcom, Ltd., of Birmingham, to give an output of 1000 cubic feet of free air per minute against 80 lb. per square inch terminal pressure. The machine by Daniel Adamson and Co., Ltd., of Dukinfield, illustrated in Fig. 51 on page xviii, has a capacity of 12,000 cubic feet of free air per minute compressed to 100 lb. per square inch gauge, and is driven by a high-pressure steam turbine running at 4000 r.p.m. These makers construct small plants down to 2000 cubic feet per minute capacity, and claim that their efficiencies are very little below those of larger plants. They also construct much larger machines than that illustrated, and by placing two cylinders in tandem have reached pressures of 240 lb. per square inch.

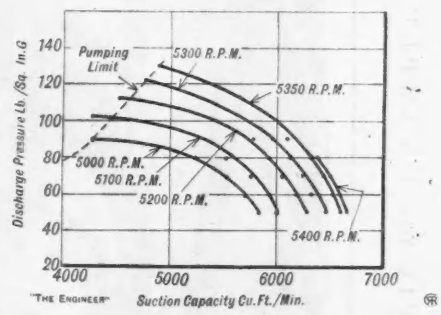
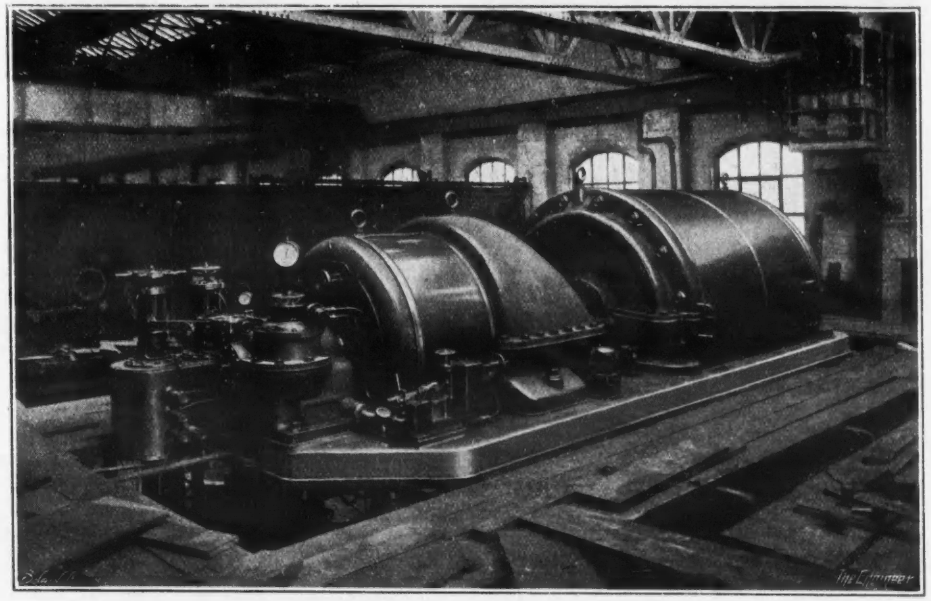
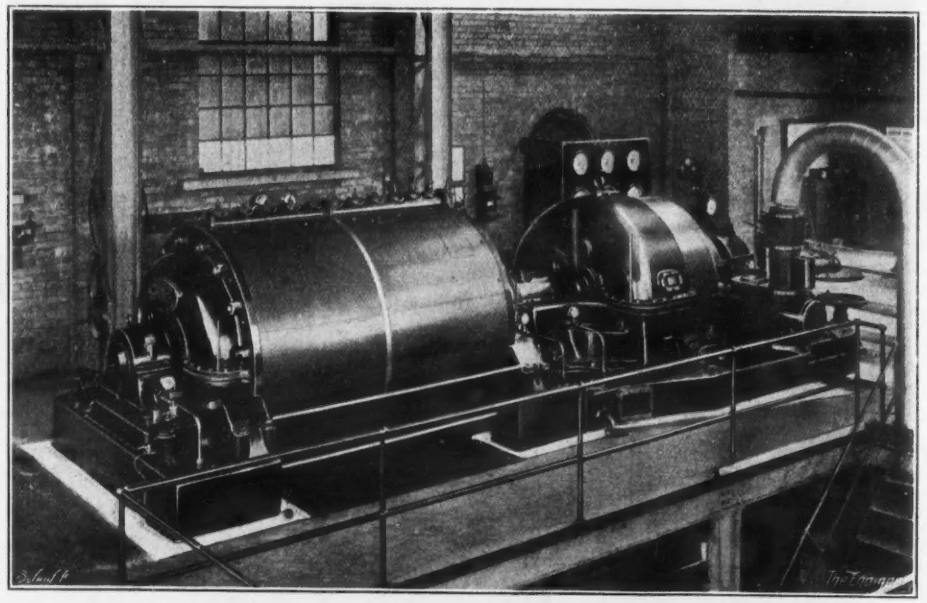


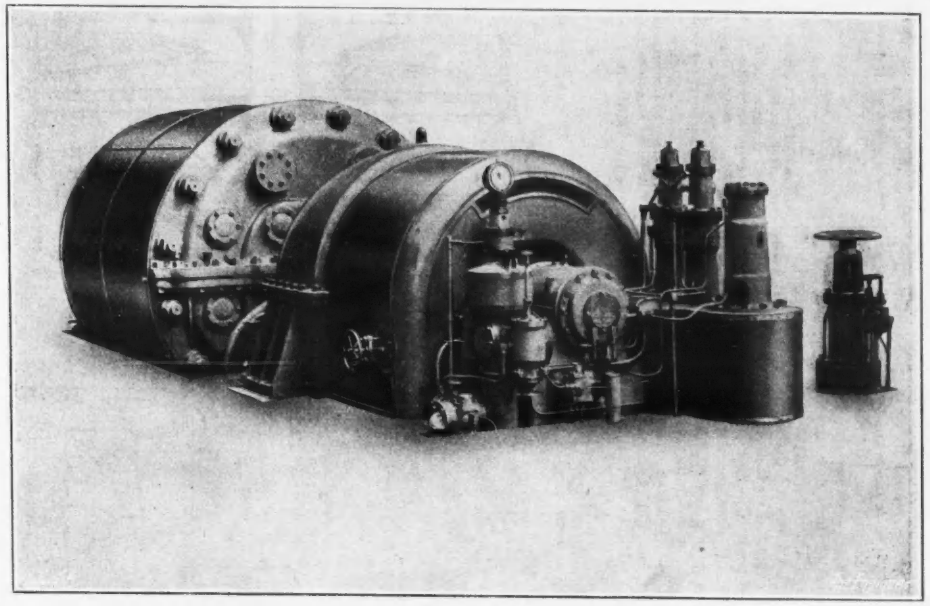
FIG. 50—PRESSURE-VOLUME CURVES—ADAMSON

Control of Turbo-Blowers and Compressors.—The most generally adopted arrangement for the control of turbo machines is a combination of means for altering the speed of running with an additional device which will "unload" the machine if the volume to be delivered is below the pumping limit. The manner in which such controls work is best illustrated by considering the characteristic pressure-volume curves of a typical machine. In a test of a Daniel Adamson machine to deliver 6000 cubic feet of free air per minute against 80 lb. per square inch

TYPICAL EXAMPLES OF TURBO-COMPRESSORS AND BLOWERS







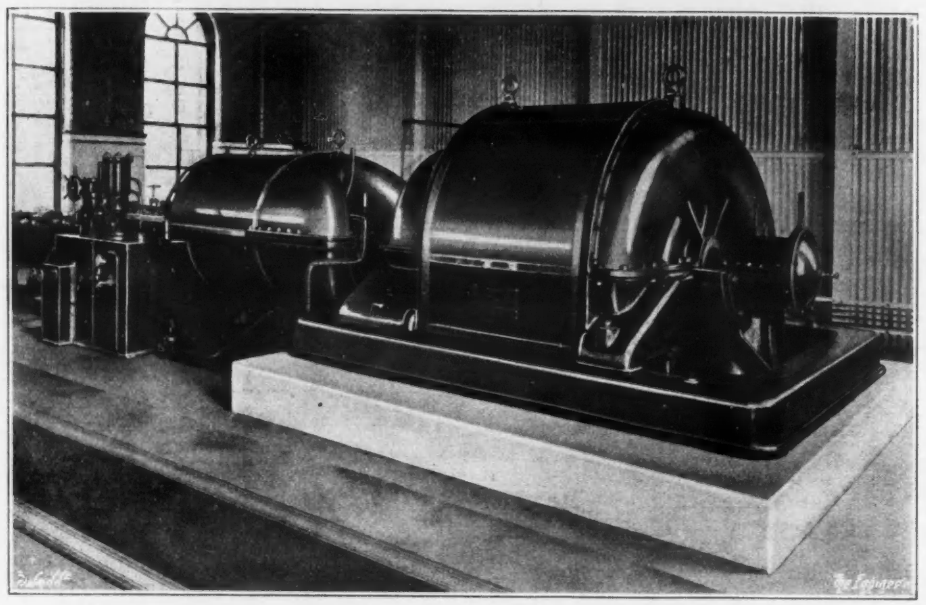


FIG. 51—STEAM TURBINE-DRIVEN TURBO-COMPRESSOR—ADAMSON
FIG. 53—COLLIERY TURBO-COMPRESSOR—HICK, HARGREAVES

FIG. 52—TURBO-COMPRESSOR OF 1000 CUBIC-FOOT CAPACITY—BELLISS
FIG. 54—FOUR-STAGE SINGLE FLOW BLAST FURNACE BLOWER—FRASER

gauge, the curves shown in Fig. 50 were obtained. It will be seen that the duty is achieved at a speed of rather more than 5200 r.p.m. If the demand were to drop to, say, 5000 cubic feet per minute, the discharge pressure would rise. But by actuating a control by means of the discharge pressure the speed could be reduced and the pressure would thereby be held nearly constant. In the particular machine under consideration a delivery of 5000 cubic feet per minute against 80 lb. per square inch could be obtained at a speed of rather less than 5000 r.p.m. But the speed and the delivery cannot indefinitely be reduced. At a delivery of rather more than 4000 cubic feet per minute against 80 lb. per square inch pressure, according to the graph, the pumping limit is reached. At smaller deliveries the action of the machine would become unstable and surging would occur. If the demand therefore falls below this limit, it is necessary to "unload" the machine and rely upon the storage in the mains to maintain the output temporarily until the pressure has fallen sufficiently to allow the machine to operate at a higher loading.

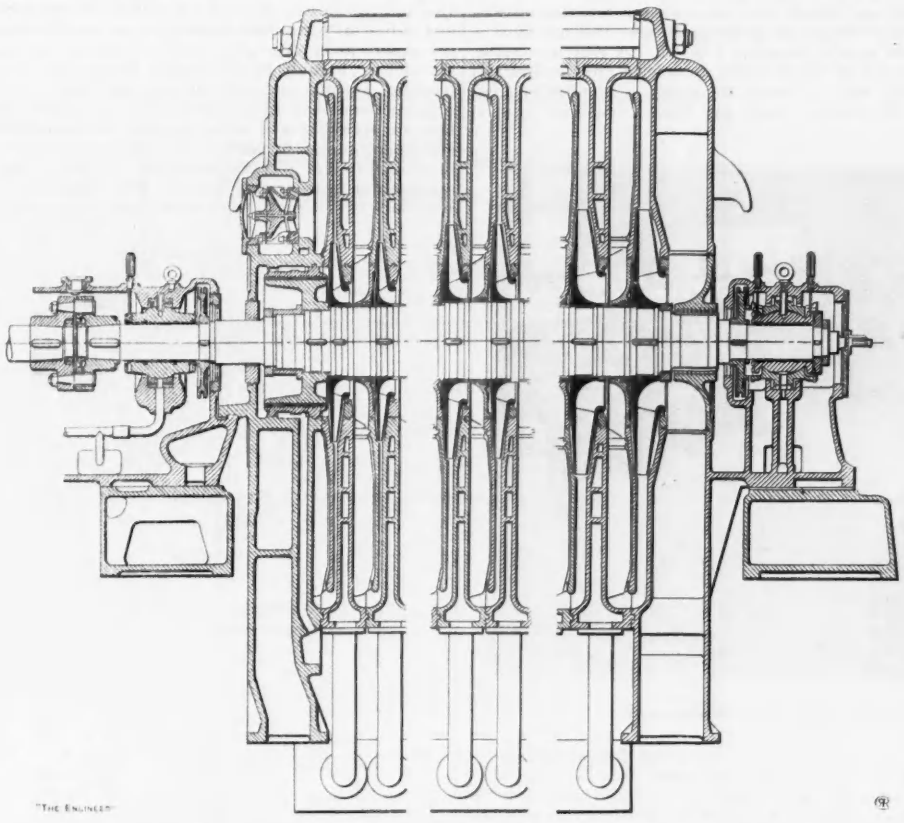


FIG. 55—TWELVE-STAGE TURBO-COMPRESSOR—HICK, HARGREAVES

The general intention of the controls designed by all the manufacturers is the same, although the mechanism is different. All Daniel Adamson machines driven by turbines or by variable-speed motors are fitted with, first, a speed control operated by the pressure in the delivery main, and, secondly, with an air suction control which, when the pumping limit is approached, closes the air suction valve. A non-return valve in the air main then automatically closes. Just after the suction valve is closed, the air suction controller causes a small auxiliary valve on the discharge end of the machine to open and the air pressure within the body of the machine is thus relieved, and, indeed, the earlier stage rotors run in a partial vacuum. This arrangement reduces windage and skin friction losses. When the prime mover is such that its speed cannot be altered, control of the output is effected by suction throttling followed by complete closure of the suction valve as the pumping limit is approached.

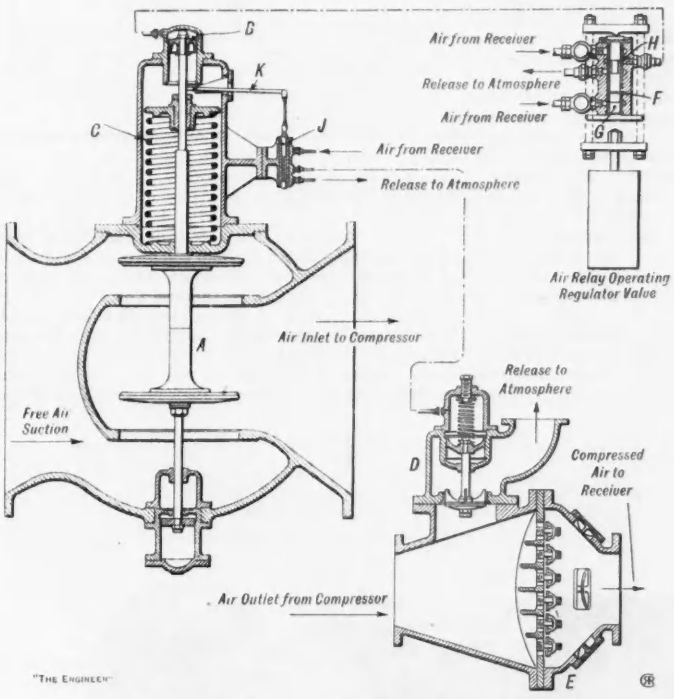


FIG. 56—"UNLOADING" ARRANGEMENT—PARSONS

The arrangements adopted by C. A. Parsons for effecting "unloading" are illustrated in Fig. 56. The air control valve A in the inlet main of the compressor is operated by the piston B against the action of the spring C, which normally holds the valve open. An automatic relief valve D and a multiple port non-return valve E are fitted between the compressor outlet and the air receiver. An air governor F is connected by pipes to the receiver and to the air control valve A. The plunger G of the air governor is loaded by deadweight, so that it will lift when a predetermined air pressure is reached in the receiver. It therefore admits air at the receiver pressure to the operating cylinder of valve A, causing this valve to close. The plunger G and the bush H are so arranged that G will remain lifted and the valve A closed until the pressure in the receiver has fallen to the lower limit of the permissible pressure. Just as the valve A is closing the plunger J of the air relay is lifted by the lever K. This allows air at the receiver pressure to open the relief valve D, while the non-return valve E closes at the same time. The compressor then runs "unloaded." When the air pressure in the receiver falls below the lower permissible limit, the above operations are reversed and the compressor runs under normal load conditions, the non-return valve E opening automatically.

The controls of turbo machines made by Metropolitan-Vickers Electrical Company, Ltd., of Manchester, are actuated to achieve like results through the medium of an oil relay system. In this case, however, the automatic discharging valve is opened just before the suction valve is closed, and in the reverse direction is closed again after the suction valve has opened. Both Parsons and Metrovick, like other manufacturers, provide for speed control of the prime mover for variation of output in the range above the surging point.

The governing gear on Fraser and Chalmers machines also operates through the medium of an oil relay and is illustrated in Fig. 57, which shows the gear in the setting for normal running. It will be noticed that a "flap" A is used for measuring the air flow. If the flow falls in consequence of reduced demand, this flap drops and causes the pilot valve E to move into such a position that pressure oil is admitted underneath the power piston D, the consequent movement of which closes the butterfly valve B in the suction pipe and opens the relief valve C to atmosphere. The non-return valve G automatically closes. Supposing that, though reduced the demand for air still continues, the pressure in the air main beyond the non-return valve will fall. As it does so, the air piston F, which is only held up by air pressure, moves downward under the influence of its spring, and thus causes the oil pilot valve E to return to its neutral position thereby releasing the oil in the power cylinder D, and causing the butterfly valve B to open and the relief valve C to close. The compressor now begins to deliver air into the mains again, the flap A is raised, the non-return valve opens, the incoming mains pressure forces the air piston F into its top position, and the cycle will continue until such time as the demand increases to an amount greater than the pumping limit when a steady condition will be reached with the butterfly valve open.

Besides constant pressure regulation, constant volume regulation is sometimes called for, particularly for the service of blast and other furnaces, where it is an advantage to know more precisely the amount of oxygen entering each minute. The only alteration of the control gear required is that the actuating relay shall be operated by a "detector," not for pressure, but for volume, the other equipment for controlling the speed, &c., remaining the same. Fraser and Chalmers and Reavell and Co., prefer the use of a Reavell-Askania regulator, particularly for the more refined control required when the regulation is to be by the weight of gas passing. The same type of regulator can be used for constant pressure control, but though more sensitive it is not quite so quick in

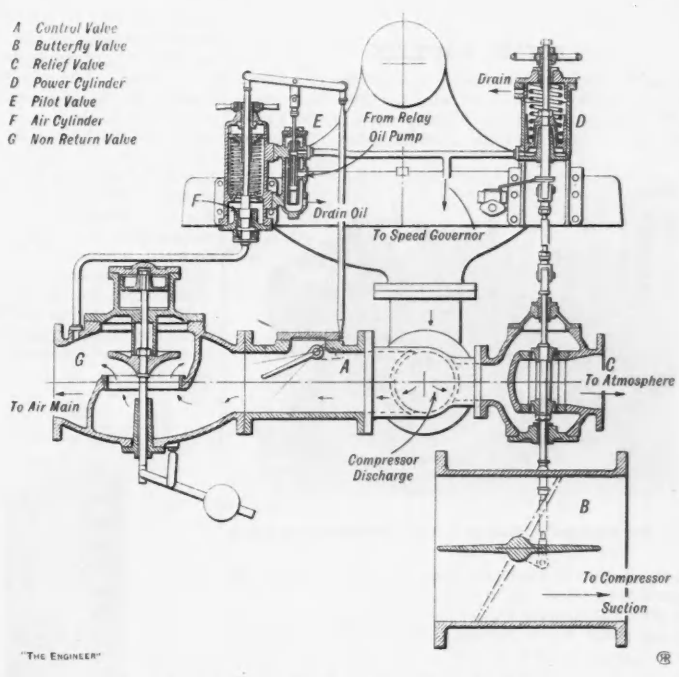


FIG. 57—OIL RELAY GOVERNING GEAR—FRASER

response to rapid changes of operating conditions, and under such circumstances spring-loaded or gravity-loaded devices may be considered preferable. The Reavell-Askania device has been described in the pages of The Engineer before, and will be familiar to our readers.

Another interesting arrangement which has been developed by Fraser and Chalmers Engineering Company, Ltd., enables a compressor to run and to deliver steadily quantities well below those corresponding to the pumping limit right down to zero. When the air demand falls below the pumping limit, the arrangement is such that the compressor continues to deliver an amount slightly in excess of that limit. The surplus air is automatically directed to the nozzles of an air turbine mounted on the compressor shaft and exhausting into the compressor suction. The prime mover is thus relieved of a proportion of the load, while the air exhausted from the turbine, being at a low temperature, improves the performance of the compressor. The makers remark that although this method of regulation is actually less efficient than that of intermittent delivery, it has the advantage of maintaining a constant delivery pressure. It also has advantages when a compressor is driven by a mixed pressure turbine. With the method of intermittent delivery the compressor may change over to zero delivery at the moment the maximum flow of low-pressure steam occurs, so that a portion of it cannot be utilised. With air turbine governing, such a condition cannot arise. The control is simple, consisting of a relay which gradually opens a by-pass from the discharge to the turbine nozzles as the pressure rises.

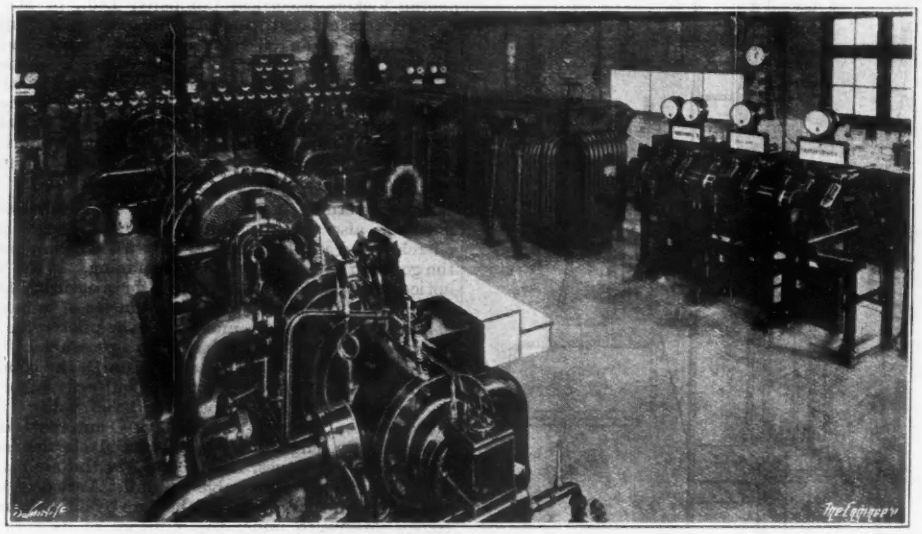


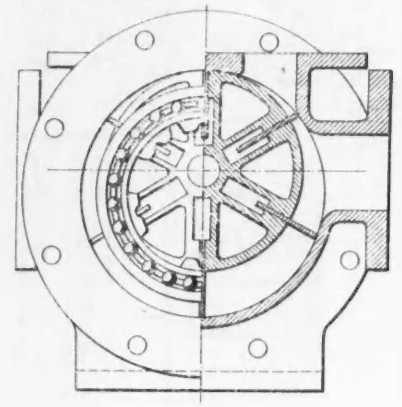
FIG. 58—TWO-STAGE ROTARY COMPRESSOR INSTALLATION—HOLLAND

ROTARY MACHINES.

Vane or Crescent Machines.—Besides the reciprocating and turbo-compressors already described, there are various rotary types distinguished from turbo-machines in that they are positive acting. Some of them, and particularly the vane or crescent machines, drawings of which are reproduced in Figs. 62, 63, and 64, combine to some extent the advantages of reciprocating and turbo-compressors. Though positive acting, they are able to run at very high speeds and are therefore compact. They have a simplicity almost equal to that of turbo-machines, and though they suffer from reduced efficiency as the delivery pressure increases and their efficiency is liable to be rather sharply affected by the incidence of wear unless they are very carefully designed and constructed, they take the place of turbo machines for small deliveries under about 3000 c.f.m., at which level the latter machines begin to suffer a reduction in efficiency. A typical example of one of the machines to which we refer is illustrated in Fig. 60. It is made by Hick, Hargreaves and Co., Ltd., in a range of sizes covering outputs from 8 to 2700 cubic feet per minute at pressures from 1 lb. to 150 lb. per square inch, and the same machines may be used as exhausters and vacuum pumps to produce vacua as large as 99·5 per cent. of the barometer. Machines of this type have the advantages that they can be directly connected to high-speed electric motors, that they have no valves likely to break or get out of order, and that the flow of air is continuous and not pulsating. They are, moreover, simple to operate and maintain. The internal design of a Hick, Hargreaves machine is shown by the drawing, Fig. 62. A cast iron rotor is mounted excentrically in a cast iron cylindrical casing, and is slotted to receive a number of free-moving blades which are forced outwards centrifugally when the rotor turns and thus divide up the crescent-shaped working space into a number of separate chambers. Restraining rings with an internal diameter slightly less than that of the cylinder rotate freely within it at each end under the influence of the moving blades which bear against them. By this means the ends of the blades are held just clear of the stationary cylinder and there is no frictional contact. Owing to the fact that the peripheral speed of the end of each blade varies according to its extension from the rotor, there is a rubbing action between the blades and the restraining rings over a small arc, but at so low a relative speed that the friction is small and wear inappreciable. The suction port extends around nearly one half of the periphery of the cylinder. But the discharge port is more restricted. It will be observed that each of the chambers into which the working space is divided becomes smaller as the discharge port is approached so that compression takes place gradually as the rotor turns. The size of the discharge port is thus related to the pressure against which the machine is to deliver, since it is desirable that as each space opens to discharge, its contents should have been compressed to discharge pressure. The machine therefore suffers a loss of efficiency when working against pressures for which it was not designed. For high-pressure conditions or high vacua two such compressors are placed in series. Water cooling is adopted whenever the discharge pressure exceeds 7½ lb. per square inch, and in vacuum pumps for vacua exceeding 35 per cent.

Machines of this kind are easily adapted to be controlled by an automatic governor, which, when a predetermined receiver pressure is reached, causes a suction valve to close, or, in electrically driven units, operates a "start" and "stop" gear. It is desirable in any case to fit a non-return valve on the discharge side to prevent the machine motoring in the reverse direction should the drive fail from any cause.

The installation of rotary compressors, illustrated in Fig. 58, was supplied by the B. A. Holland Engineering Company, Ltd., of London and Slough, to the Chippenham works of the Westinghouse Brake and Signal Company, Ltd. There are three two-stage compressors, each driven by an 108 H.P. auto-synchronous motor. Each machine delivers 500 cubic feet of free air per minute against a pressure of 100 lb. per square inch. The air is used in various parts of the factory, notably in the foundry for riddling, sand blasting, fettling, and core-blowing machines, in the constructional shop for pneumatic riveting, in the paint shop for spraying, and in the rectifier department for the operation of furnace doors, the air cooling of certain types of rectifier discs, and for the metal spraying of large copper plates. The design of the machines is similar to that of the compressors mentioned in the previous paragraphs. Restraining rings are used and the blades have a small clearance within the casing.



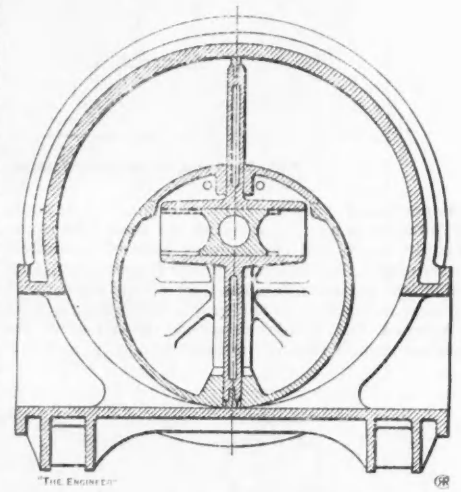


FIG. 61—SIX AND TWO BLADE BLOWERS—DONKIN

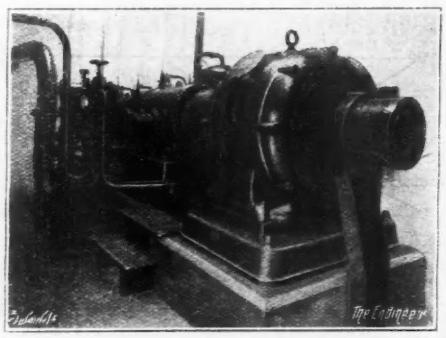


FIG. 59—AMMONIA ROTARY COMPRESSOR—HOLLAND

Another machine, illustrated in Fig. 59, is used for the movement of ammonia gas at one of the works of Imperial Chemical Industries, Ltd. Two similar compressors are driven in tandem and connected in parallel to common suction and delivery mains. Fluctuations in gas demand are met by an automatic by-pass valve, which returns surplus gas to the inlet main. Tests carried out on site showed that after 26,400 hours of running during a period of more than

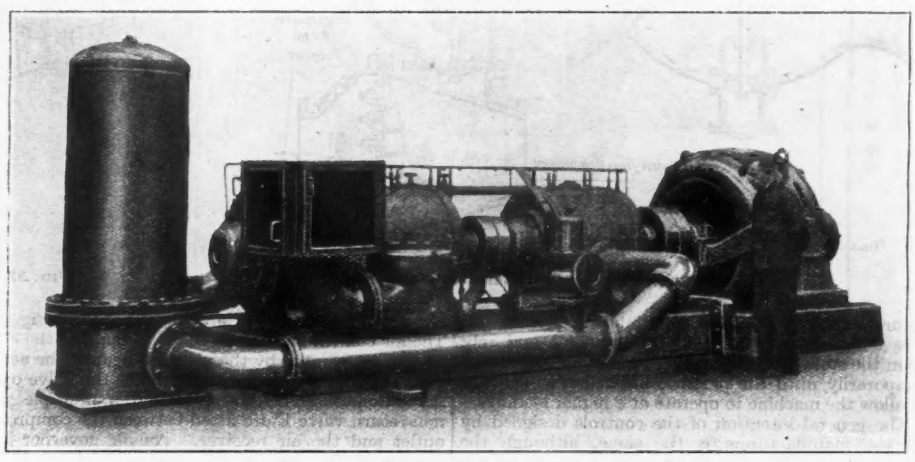


FIG. 60—TWO-STAGE ROTARY BLOWER—HICK, HARGREAVES

five years the output had fallen off by only 3·2 per cent. Examination showed, we are informed by the makers, all working parts and clearances in first-class order. Only the roller bearings exhibited signs of wear, but of so slight a character that replacement was not deemed necessary.

Similar machines are made by Worthington-Simpson, Ltd., of Newark-on-Trent, and Reavell and Co., Ltd., of Ipswich, and their designs are shown by the drawings, Figs. 63 and 64. The first-named concern builds rotary compressors in capacities up to 3000 cubic feet per minute and for pressures up to 60 lb. per square inch. By utilising two-stage compression, pressures up to 150 lb. per square inch are attainable. We are informed by the firm that the efficiencies of single-stage units for pressures up to 25 lb. per square inch compare satisfactorily with those of reciprocating machines. The design of the machine is similar to that by Hick, Hargreaves in that restraining rings are used. They are a running fit in the cylinder and are designed to carry the unequal centrifugal thrust of the blades, the forces resulting from the progressive compression of the air, and the frictional resistance to be overcome in forcing the blades inwards towards the centre of the rotor. These forces, it will be noted, add up to a considerable unbalanced thrust on the restraining rings. It will also be observed that each ring is well supported to take the thrust and that oil-sealing chambers are provided between it and the cylinder to prevent leakage around its outer periphery. A keep ring maintains each restraining ring in position. The general design can be easily followed from the drawing, but particular attention may be directed to the means adopted for sealing the shaft and to the special adjustable ball location and thrust bearing used to locate it. As a typical example of performance, a machine giving 108 cubic feet of free air per minute at 15 lb. per square inch runs at 1450 r.p.m. and absorbs 8·75 B.H.P.

The Reavell machine differs from those just described in that it has a "rolling drum" completely encircling the rotor and blades instead of restraining rings. This drum, which consists of an accurately machined and ground cylinder running on ball bearings fixed in the end covers of the casing, is pierced with holes for the entry and discharge of air and revolves freely under the influence of the blades. The interior of the cylinder into which it fits is also ground and a very fine clearance exists between the two and prevents undue leakage. As compressors these machines are supplied for pressures up to 30 lb. per square inch, and as exhausters up to 24in. of vacuum and within this range their efficiencies compare favourably with reciprocating machines. They can of course be used in series to obtain high pressures or vacua. The makers suggest them as suitable for such purposes as the aeration and agitation of liquids, pneumatic despatch and transport, atomising oil for burners, sand blast apparatus, &c., besides ordinary purposes for which air at pressures up to 30 lb. per square inch is used. The smaller machines run at speeds up to 2600 r.p.m., giving at that speed 88 cubic feet of free air compressed to 15 lb. per square inch or 102 cubic feet to 5 lb. per square inch or intermediately, the powers required being 8¼ B.H.P. and 5 B.H.P. respectively. The largest machine, running at 600 r.p.m., compresses 3200 cubic feet or 2700 cubic feet to 5 lb. or 15 lb. per square inch respectively, and the powers required in this case are 109 B.H.P. and 222 B.H.P. Water-jacketed machines are recommended for pressures exceeding 15 lb. per square inch.

A blower of the same kind, with six blades, made by the Bryan Donkin Company, Ltd., of Chesterfield, is illustrated by the upper drawing in Fig. 61. Machines of this kind were introduced by the firm some years ago for the compression of small volumes to relatively high pressures. As compared to other machines

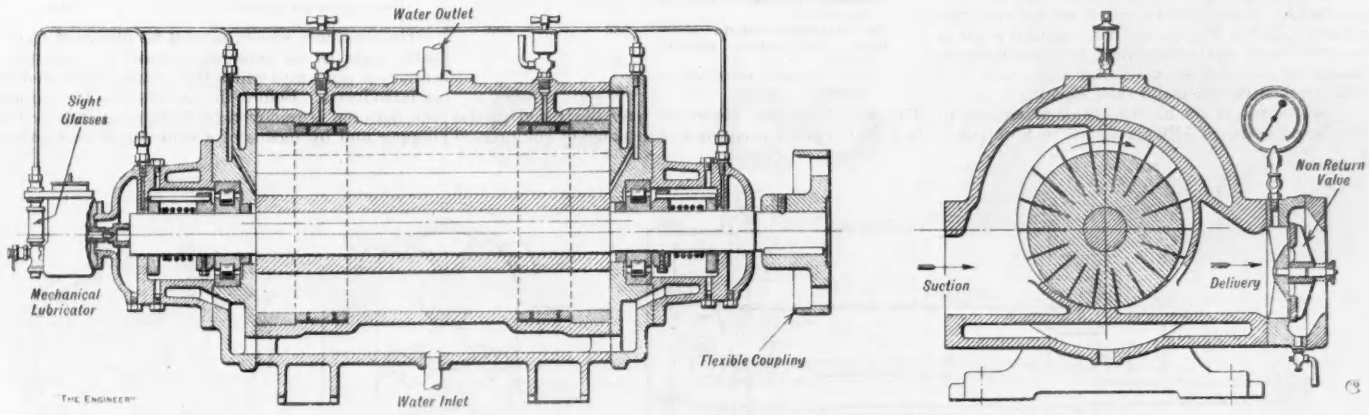


FIG. 62—SECTIONS THROUGH MULTI-VANE ROTARY BLOWER OR EXHAUSTER—HICK, HARGREAVES

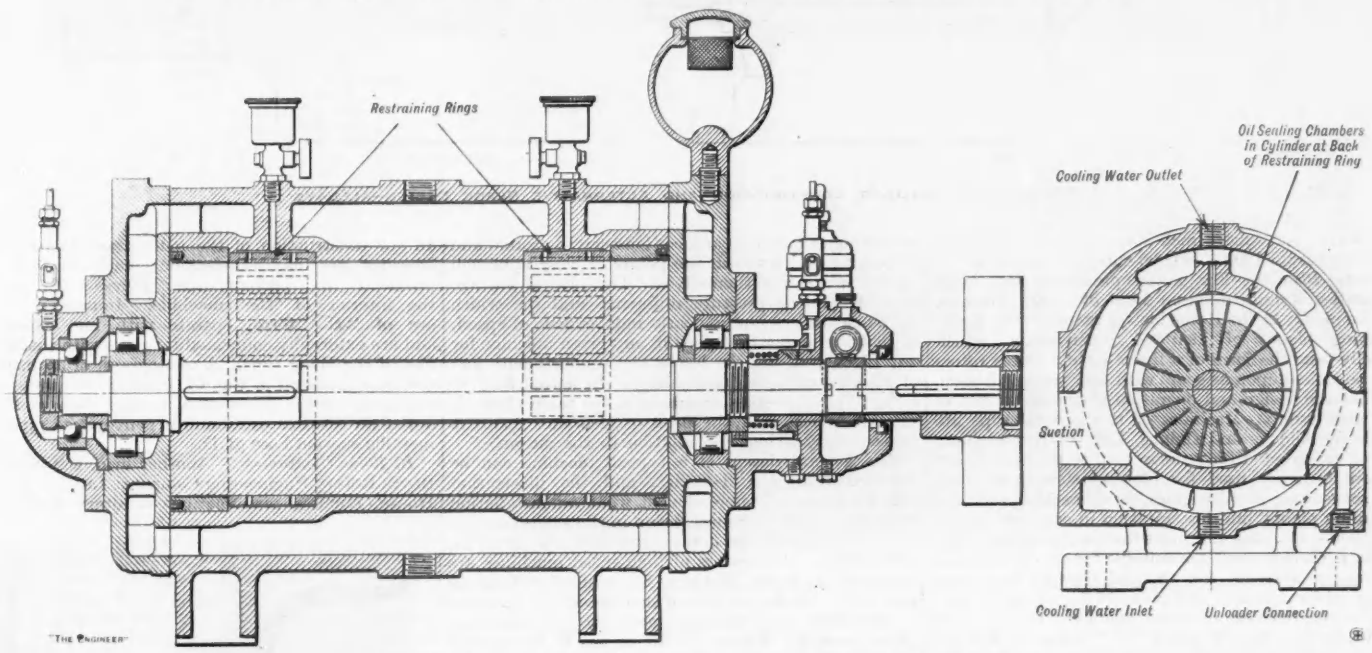


FIG. 63—ARRANGEMENT OF TYPICAL ROTARY COMPRESSOR—WORTHINGTON

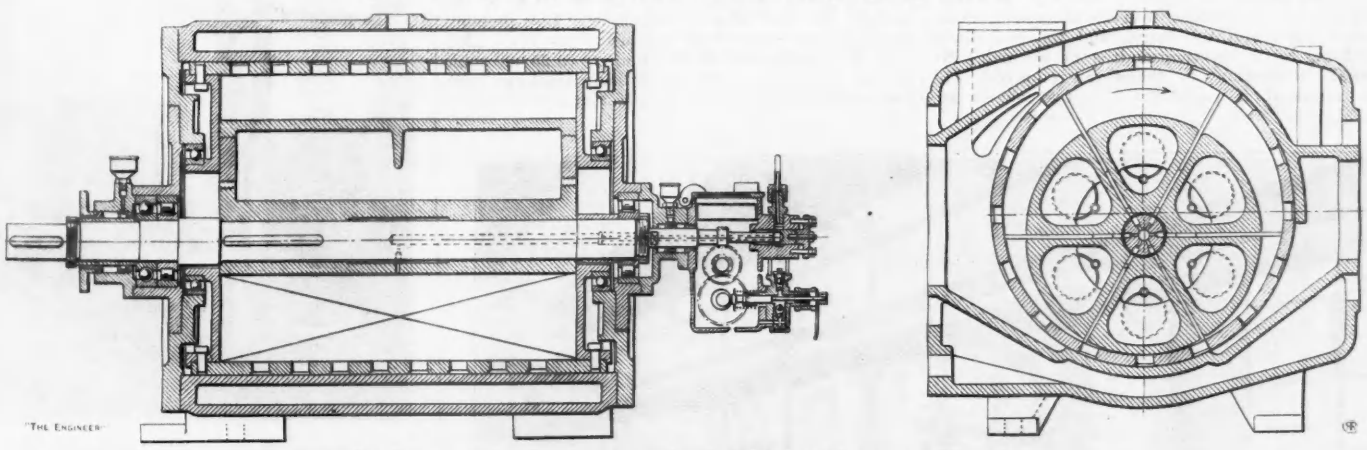


FIG. 64—ARRANGEMENT OF SIX-BLADED ROTARY COMPRESSOR—REAVELL

of the same general design, it will be noted that the blades are prevented from coming actually into contact with the casing, not by a drum or by restraining rings, but by having tongues at the ends which fit into grooved shoes that bear against the inner races of ball bearings. The grooved shoes are necessary because the blades, being radially set in a rotor excentric to the casing, do not bear radially against the casing, except at two points in their circuit. These blowers are suitable for pressures up to 10 lb. per square inch and water cooling is employed in all machines for more than 5 lb. per square inch pressure. They run at speeds up to 1400 r.p.m.

Another similar blower made by the same firm has only two blades controlled in the manner shown in the lower drawing in Fig. 61. The cast iron cylinder is bored to the exact oval shape described by the excentric movement of the blades, which are supported and guided by the central block and axle. Packing strips are inserted in the ends of the blades. Such machines are suitable for pressures of 5 lb. per square inch uncooled and 10 lb. per square inch water cooled, and have capacities from 100 to 500,000 cubic feet per hour.

Roots Blowers.—For lower pressures and large quantities a quite different kind of rotary machine can be used. In the Roots blower there are two intermeshing blades of identical construction, which usually take the form of a figure eight. These rotors can be looked upon as gears with only two teeth each, so that the design and operation is similar to that of the gear pump. Machines of this general type are made by Alldays and Onions, Ltd., of Birmingham. Those constructed for pressures up to about 5 lb. per square inch are used for blowing steel converters, for scavenging in oil engines, in connection with ash handling plants, and for agitation in connection with ice plants, &c., while machines for lower pressures up to 1½ lb. per square inch are suitable for cupola blowing, pneumatic systems, &c. Special blowers have been designed for pressures as high as 10 lb. per square inch

The construction of these machines is shown by drawings Fig. 65. A letter "H" shape is adopted for the rotors of high-speed machines, except in the larger sizes, where the figure 8 design is preferred. The rotors are made of cast iron and there is clearance between them and the casing and the end plates amounting to a few thousandths of an inch. No internal lubrication is therefore required. The blast obtained is positive. The two shafts are externally geared together to retain the correct angular relationship between the rotors and there is no actual contact as between the rotors. The makers state that although the high-speed machines generate more noise than the slower machines, yet by the fitting of hardened and ground steel timing gears and applying suitable silencers the noise can be very effectually reduced. High-speed machines have a higher efficiency than the slower machines, as is shown by the following comparative table :—

	High-speed machine.	Low-speed machine.
Displacement capacity, cubic feet per minute	2040	2040
Discharge pressure, pounds per square inch	5	5
Revolutions per minute	680	400
Brake horse-power, approximately	50	52
Free air delivered, cubic feet per minute	1550	1330

The reason for this difference may be traced to the fact that there is a continuous leakage of compressed air through the fine clearances between the rotors and the casing and between the points of close approach of the two rotors themselves. The rate of leakage depends on the pressure difference and the width of the clearances and is nearly independent of speed, so that the higher the speed in any given machine for any given pressure the less is the proportionate loss of delivery owing to the leakage. In actual fact, of course, the high-speed machine in the table above is smaller in size and the area of clearance space is consequently reduced in relation to the output.

The general design of a typical machine can be followed from the drawings, and the illustration Fig. 66 gives an impression of what an installation looks like. The machines shown in this engraving are of the slow-speed type and are installed in an artificial silk factory. The rotors of high-speed machines are mounted on roller bearings, but ring-oiled bearings are used in the larger sizes of slow-speed high-pressure blowers and when handling gases the end plates are gland packed. Where the air or gas to be handled contains any substance that may be deposited on the working parts, cleaning doors can be fitted to the casings of the larger machines. Low-pressure machines are made with displacements from 1300 cubic feet per minute at 400 r.p.m. up to 25,000 cubic feet at 240 r.p.m., and high-pressure machines with displacements from 1200 cubic feet at 400 r.p.m. up to 25,000 cubic feet at 240 r.p.m. The displacements of the high-speed machines range from 110 cubic feet at 1500 r.p.m. to 9940 cubic feet at 400 r.p.m. for low pressures and from 88 cubic feet at 1200 r.p.m. to 15,500 cubic feet at 360 r.p.m. for high pressures.

A similar type of machine is made by Davidson and Co., Ltd., of Belfast, for use in connection with the firm's pneumatic conveying plant. The leading particulars of a No. 5 machine by these makers are as follows :—

Diameter of discharge outlet	5in.
Volume of attenuated air dealt with, cubic feet per minute	420
Vacuum continuously maintained	12in. mercury
Revolutions per minute	900

The machine, which, as will be observed from the table, acts as an exhauster, draws air through the conveyor pipes into which the material to be conveyed is introduced. Before the air reaches the exhauster the material is removed by settlement into a storage hopper and by means of a centrifugal dust collector.

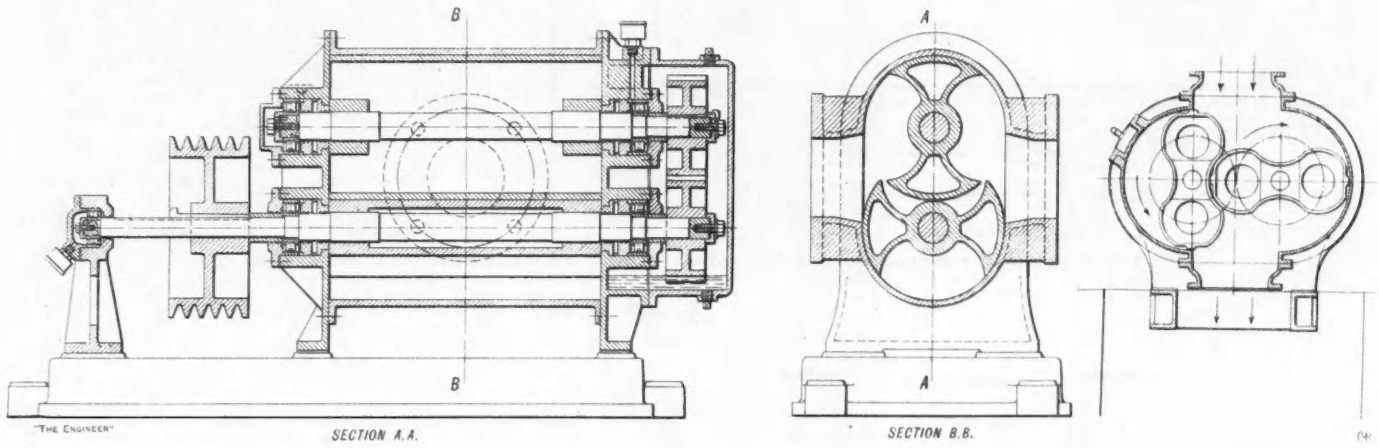


FIG. 65—ROOTS BLOWER CONSTRUCTION AND ALTERNATIVE BLADE DESIGN—ALLDAYS

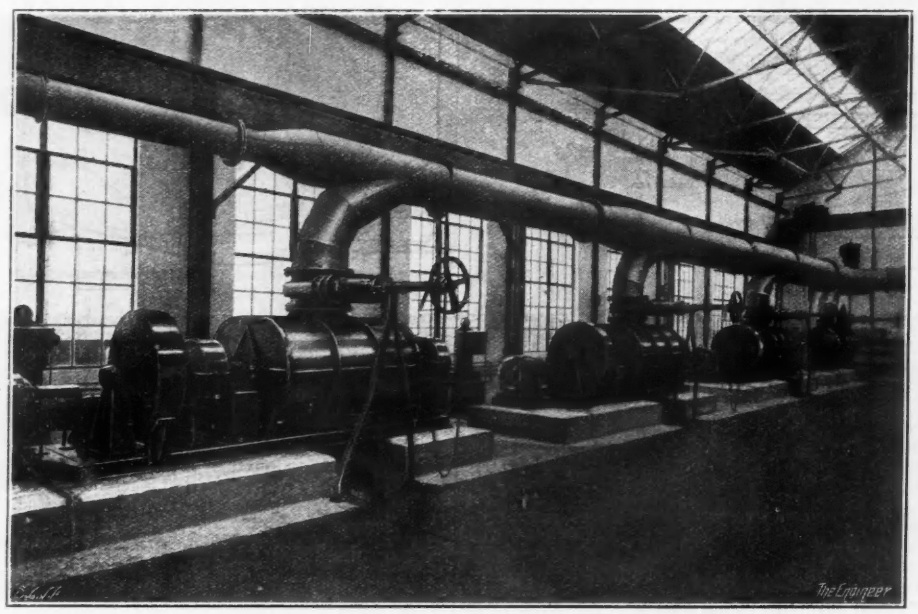


FIG. 66—INSTALLATION OF ROOTS BLOWERS—ALLDAYS

In the construction of the machines ball and roller bearings are used throughout and oil seals are provided to prevent the ingress of oil to the interior of the machine. Impellers, which are of "H" form, operate with fine clearances and are externally connected by gears with tooth profiles of the Maag type. A photograph of an installation is reproduced in Fig. 67, in which the water trap at the air inlet is shown at A, a relief valve at B, the outlet air silencer at C, and a conveyance pipe and metallic suction hose at D.

Bi-Rotor Compressor.—Another firm, the Northey-Boyce Rotary Engineering Company, Ltd., of Thames House, London, manufactures a rotary compressor

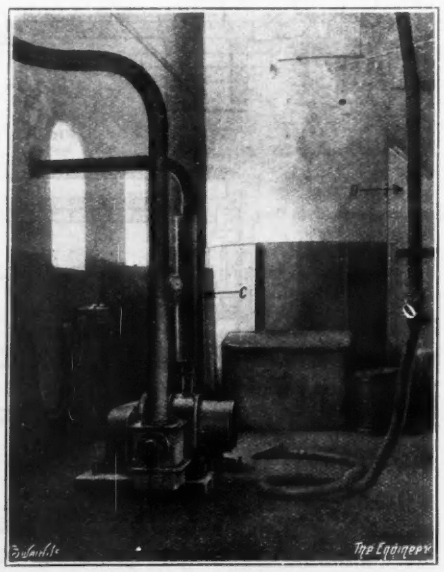


FIG. 67—ROOTS BLOWER FOR CONVEYING PLANT —DAVIDSON

or exhauster of a rather different character, which was first developed some three years ago. The general principle of operation is illustrated by Fig. 69, and the design of a typical machine by the drawing, Fig. 68. Two similar rotors of the design shown by the engravings are mounted in a suitably shaped casing and geared together externally. Two part-annular ports are formed in each of the end covers, and are alternately exposed and covered by the rotors. In the situation of the rotors shown in the first diagram (Fig. 69) the inlet port is just about to open, so that air will be drawn into the space I. Air in the spaces C is about to be compressed. When the rotors have travelled to the positions shown in the next diagram the delivery port opens and the compressed air in the

spaces C is delivered out of the machine. Meanwhile, further air is entering the increasing space I behind the rotor blades from the inlet port. The following diagram shows the conditions which exist when simultaneously the delivery and suction ports close. A small portion of the compressed charge is trapped in the space C, while the whole of the remaining space is filled with air at suction pressure. A further small angular movement of the rotors, as shown in the fourth diagram, breaks the seal which existed by their mutual contact, and the undelivered air is freed into the induced charge, thus slightly compressing it. On the seal being re-established, as in the first diagram, practically all this

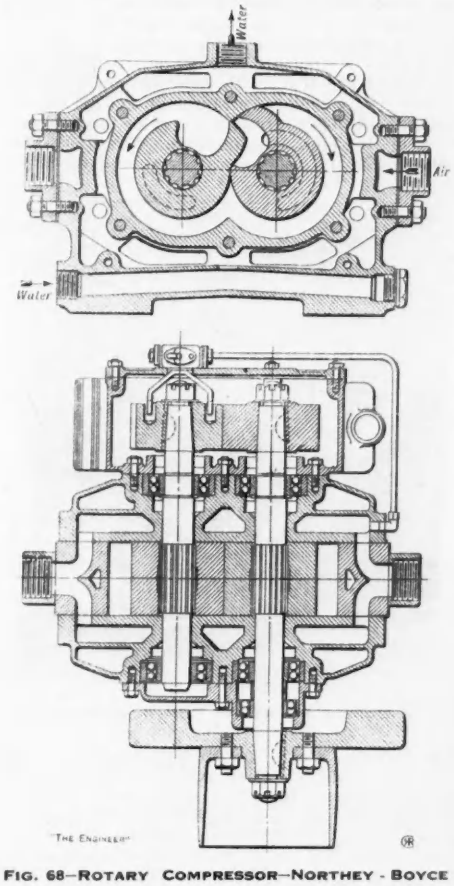


FIG. 68—ROTARY COMPRESSOR—NORTHEY-BOYCE

slightly compressed charge is found to be in the compression space C, while a slight vacuum is created in the widening space I before the suction ports open. It is therefore interesting to note that the existence of a "clearance" volume does not have a deleterious effect upon the amount of charge drawn in at each revolution, as its contents are not discharged into the suction space until after the suction stroke has been completed. Its effect, indeed, is claimed to provide a slight supercharge.

Referring to the drawing, Fig. 68, it will be seen that the two rotors are carried in ball bearings, and that substantial gears are provided to interconnect them. There is no frictional contact at any point, except in the bearings, and on the gear teeth. Fine clearances between the rotors and the casing and between the rotors themselves are depended upon to maintain the seal, and the rotors float freely on the shafts, so that there is no tendency for them to be pushed up against either cover. In consequence the machines can run perfectly satisfactorily without any internal lubrication of the rotors, and are suitable for use in

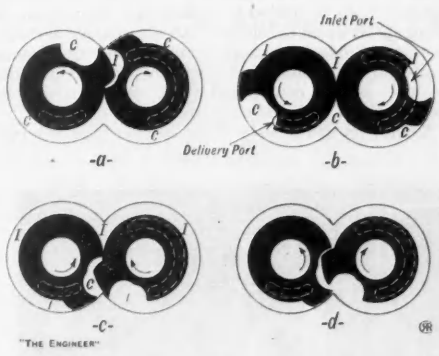


FIG. 69—CYCLE OF COMPRESSOR—NORTHEY-BOYCE

dairies, breweries, tobacco factories, chemical works, &c., where it is essential that the air or gas shall not be contaminated. By providing for lubrication, however, the seal is more efficiently maintained so that a greater output is obtained for the same power input. The machines then have efficiencies which compare favourably with other types of compressor, and are used for general services. These compressors and vacuum pumps are now made in a range of sizes giving capacities up to 900 cubic feet per minute in single-stage and 700 cubic feet in two-stage. They all run at speeds of over 1000 r.p.m., and the smallest are suitable for speeds of 2400 r.p.m. Single-stage vacuum pumps can maintain absolute pressures of ½in. of mercury, while single-stage compressors can deliver against pressures up to 60 lb. per square inch. Both air and water-cooled types are constructed, and an air-cooled machine is illustrated in Fig. 71. A recent application developed by the firm in conjunction with Gresham and Craven, Ltd., is the use of Northey-Boyce exhausters for train brake operation. For this purpose an air-cooled machine is coupled to a variable-speed motor.

Liquid Vacuum Pump.—One other rotary machine remains to be mentioned. Unfortunately, however, as the makers do not wish to reveal its internal con-

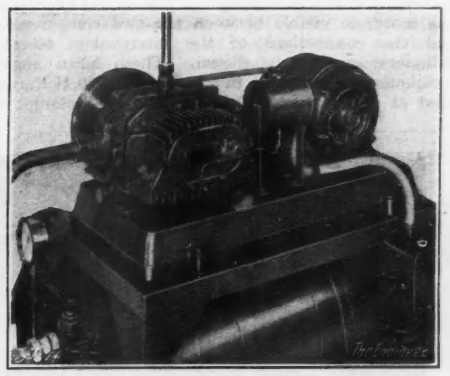


FIG. 71—AIR-COOLED MACHINE—NORTHEY-BOYCE

struction, little can be said about it. The makers, Drysdale and Co., Ltd., of Glasgow, term the device the "Aquair" rotary vacuum pump and state that it consists of two rotors revolving in a casing of special form, which has been filled by a sealing liquid. When the rotors revolve, since the casing is of varying diameter, the liquid is made to flow from and return to the centre of the rotors, and this motion is taken advantage of to draw air through one set of ports and discharge it after compression through another set of ports. The pump casing is divided horizontally and the suction and discharge connections are in the lower half, so that the design is similar to that of a centrifugal pump. A machine of this kind is shown in Fig. 70.

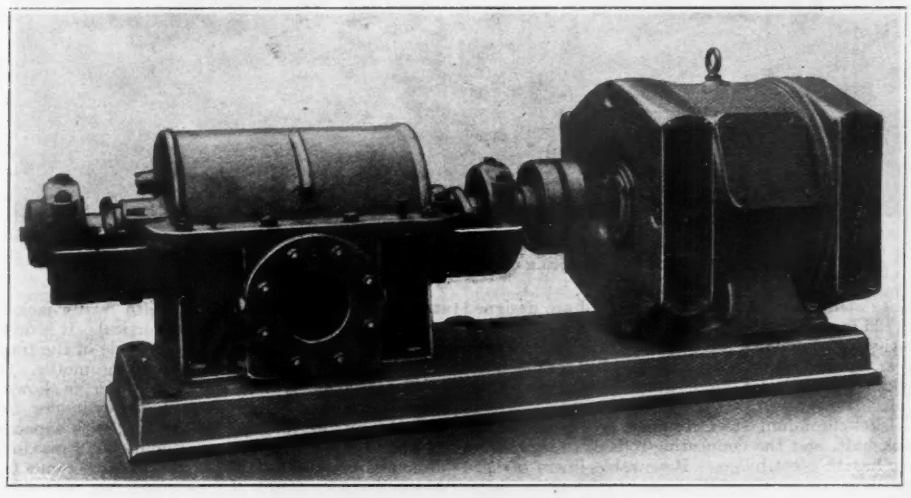


FIG. 70—"AQUAIR" ROTARY VACUUM PUMP—DRYSDALE

American Practice.

COMPRESSION of air and gases for innumerable commercial and industrial purposes, as well as for industrial and scientific research, has been developed to a high degree in America, extending to machines of vast capacity and for very high pressures. With so many manufacturers of air compressors, the various sizes and designs, the various methods of driving, and the great varieties of valves, control devices and other details, this review can give only a selection of examples as illustrative of the general line of machines. Most manufacturers have a wide range of sizes and types for different requirements, although some confine themselves mainly to the larger or smaller classes. And while there is general similarity in certain types, each manufacturer has his own special or patented details and devices.

These various machines may be driven by engines or motors directly connected to the compressor shaft or indirectly connected through gearing. or they may be driven through the medium of flat belts, multiple belts or ropes, or silent chains. In cylinder design there are two rather opposite practices. In one, the barrels are of such thickness as to permit of reboring, while in the other they are of minimum thickness, with renewable liners of wear-resisting metal. Special grades of cast iron are used for cylinder castings and various alloy steels for connecting-rods and other working parts. Roller bearings and forced-feed lubrication are in common use.

For compressors of moderate capacity many makers have a line of compact machines in which the cylinders are in a vertical plane and either upright or inclined in V shape—sometimes both in combination. A special line of machines consists of portable compressor outfits for temporary installations, such as on road work, street paving or repair, foundations, and railway bridge and track maintenance. Finally, in addition to the various machines themselves, there is an endless line of accessories, such as air filters, air meters, separators, intake silencers, and control devices.

SULLIVAN MACHINERY COMPANY.

The "angle compound" type of air compressor is perhaps the most notable design in the series of different types and sizes of compressors built by the Sullivan Machinery Company, of Chicago. In this design there is a horizontal low-pressure cylinder at one end of the frame and a vertical high-pressure cylinder mounted above the opposite end, both driven from one crank pin, so that the centre lines of the two cylinders are only a few inches apart. The crankshaft may be direct connected to an engine or electric motor or may have a belt or multi-rope drive for the smaller machines. An intercooler is mounted over the low-pressure cylinder. This "angle" design gives a very effective balance, with nearly constant torque on the crank pin and vibration reduced to a minimum. The floor space is small and the height well within the limits of an ordinary engine-room.

A development for large installations is the "twin-angle compressor," consisting of two complete machines with a common crankshaft and driven by a motor placed between them, which has sufficient power to operate both machines under full load. Each half of the unit is balanced, whether operated independently or in conjunction with the other. A magnetic clutch connection between the motor shaft and compressor shaft may be used in place of the

usual rigidly bolted shaft coupling, for either one or both compressors. The clutch is operated from the excitation circuit and is controlled either from a push-button station or automatically in connection with the cylinder unloader system. Thus if the compressor so controlled operates under no load for a given period, the clutch is automatically disengaged until the pressure drop again engages it.

Twin-angle compressors are shown in Fig. 72 operating at a large colliery. A part of the synchronous motor is visible between the two compressors, and the connections of the intercoolers to the cylinders are clearly shown. These large angle-compound compressors, in sizes up to 1000 H.P., are used at steel works and other industrial plants, as

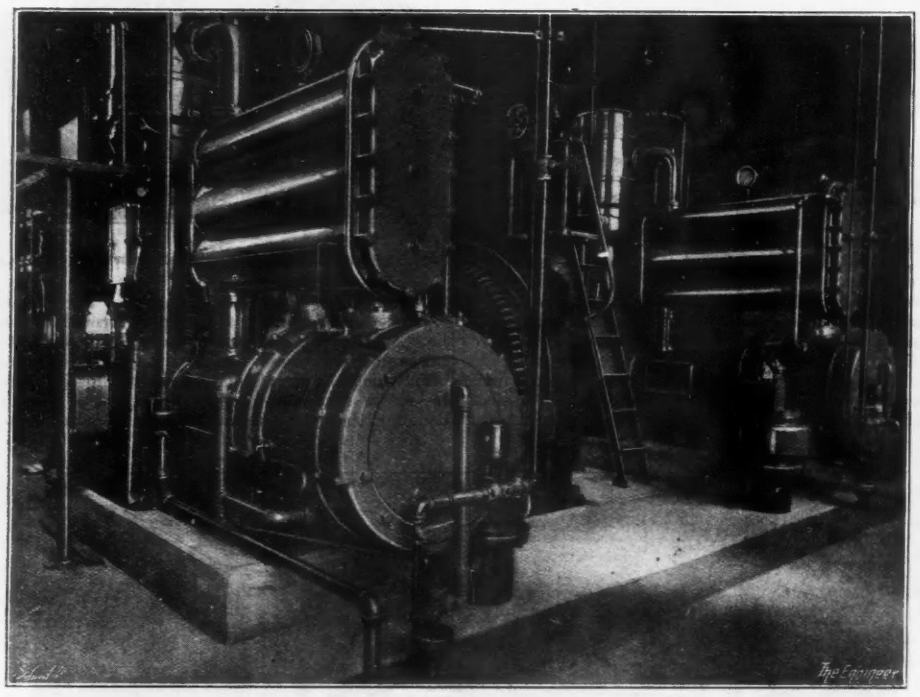


FIG. 72—TWIN ANGLE-COMPOUND COMPRESSOR—SULLIVAN

well as at mines and tunnel works. All are designed for 125 lb. maximum pressure, but two-stage and multi-stage cylinders are provided for higher pressures. Special cylinder sizes are supplied for machines working at altitudes more than 3000ft. above sea level.

Nickel-chromium steel forgings are used for the crankshaft, and the connecting-rods are forged from open-hearth steel billets. Renewable liners of hard iron have the surfaces finished by grinding after being forced into the cylinder castings. The barrels of the cylinder and a large proportion of the area of the cylinder heads are water jacketed. Inlet and discharge valves, which are interchangeable, are of the "wafer" pattern, each consisting of a flat annular ring and of a similar ring warped out of the flat so as to form a spring, the parts being assembled

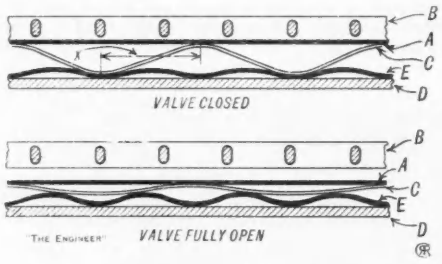


FIG. 73—DUAL CUSHION VALVE—SULLIVAN

by four bolts. Another form of valve used on these machines is the "dual-cushion" valve, which—like the other—has circular or annular ports and a four-bolt assemblage. The flat ring valve A in Fig. 73 is held against the valve seat B by the annular spring C, which is formed in a series of waves. Between the spring and the guard D there is fitted another annular reaction plate E, which also is wavy, but has its waves only half the length of those in the spring.

Tandem horizontal steam-driven compressors of the single-stage double-acting type are built by the Sullivan Machinery Company in various sizes up to 26in. by 13in. air cylinders, for pressures of 20 lb. to 125 lb., with air displacement of 280 to 2000 cubic feet per minute and running at 250 to 285 revolutions. The steam cylinder, forward of the air cylinder, has a balanced piston valve with inlet at the middle, so that the stuffing-box of the valve rod has to be sealed only against exhaust pressure. The valve is driven from an excentric.

When steam pressure and air demand are steady, regulation is effected by a constant-speed fly-ball governor for the steam and on-or-off loading of the air cylinder through pilot valve control of the inlet valves. When steam pressure is variable and air demand is constant a fly-wheel type of cut-off governor automatically shifts the cut-off valve, the air control being as above. If, however, the air demand is very intermittent, an idler or no-load regulator can be added to reduce the compressor to idling speed when unloaded. An alternative arrangement when steam pressure is steady and air demand is intermittent consists of a variable-speed throttling governor of the centrifugal type, varying the compressor speed with the air demand.

A compact compressor of the smaller class is a two-stage double-acting machine, with water-jacketed cylinders set at 45 deg. from the vertical. It is driven by an electric motor built into one side of the frame, and the intercooler is directly over the motor. One of these machines, with 100 H.P. motor, is shown in Fig. 74. These compressors have cylinders from 10+6in. by 7in. to 14½+9in. by 7in., with capacities of 378 to 800 cubic feet per minute at a maximum discharge pressure of 125 lb. The motors range from 60 to 125 H.P. Some of these machines, with direct-connected or belted motor or oil or petrol engine, are mounted on skids as complete compressor units for use on construction works.

Allis-Chalmers Manufacturing Company.

Centrifugal type blowers or turbo-blowers, rotary blowers and reciprocating compressors are among the various compressing machines built by the Allis-Chalmers Manufacturing Company, of Milwaukee, U.S.A. In the compactly arranged geared head turbo-blower, as used for cupolas, furnaces, pneumatic conveying, &c., the spur wheel on the motor shaft gears with a pinion on a short shaft which runs in two ball bearings and carries the overhung wheel. The wheel casing is bolted to the gear case and the hollow bed-plate forms an oil reservoir for the oil pump on the end of the motor shaft. Oil is sprayed into the gear case. These geared head machines are built in sizes up to 30 H.P. and for discharge pressures up to 3 lb. per square inch.

The helical gears, mounted in the end housing of the motor, are of special steel. A cast high-tension aluminium alloy is used for the impeller wheel, which is of the spider or open radial blade type, giving no end thrust on the gears. With its high rotating speed of 6450 revolutions the impeller is of small diameter, so that its tip speed is not excessive. When a constant weight of air is required, as for cupola blowing, a mechanically operated air-weight controller is provided.

Direct-connected blowers built by the Allis-Chalmers Company are of the Brown-Boveri type. In the single-stage machines, with compression effected by a single-cylinder wheel, the sizes range from 75 to 250 H.P., with capacities up to 100,000 cubic feet per minute, at pressures up to 6 lb. Electric motors with direct connection may be used for pressures up to 3 lb., but for higher pressures speed-increasing gears may be necessary, and direct-connected steam turbines are generally applied for high-pressure machines. Air drawn in at the centre by the rapidly revolving wheel is thrown out at high velocity and increased pressure from the periphery of the wheel to a concentric diffusing chamber, in which the velocity is reduced, with a corresponding increase in pressure. The air then passes to the discharge volute, which is designed to give a further increase in pressure.

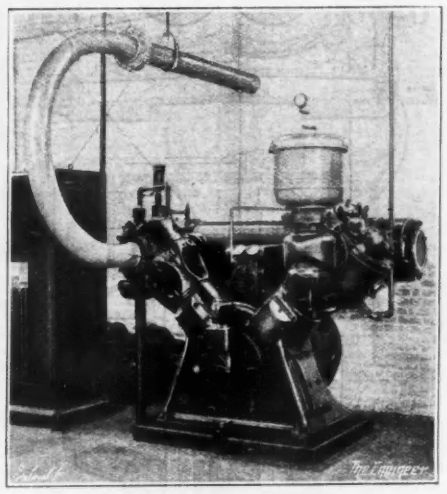


FIG. 74—DOUBLE-ACTING VEE COMPRESSOR—SULLIVAN

Overhung wheels are used generally for speeds up to 3600 revolutions and 3 lb. pressure, the wheel being of a cast aluminium alloy to reduce weight, although steel wheels may be used on the larger machines. The wheel is a solid disc, having radial blades on the face, backward blading being sometimes required to meet special conditions. A development is the double-inlet machine to avoid excessive increase in size where large volumes of air have to be handled at low pressure. In this case the impeller is a double wheel, shrouded on both sides and having a partition separating the two rows of blades. For handling gas a seal on the shaft prevents leakage of gas and infiltration of air. Where the gas is corrosive special metals may be used for the wheel and casing. A silencer on the suction inlet will prevent objectionable noise due to the inrush of air.

In the multi-stage centrifugal blower there is a

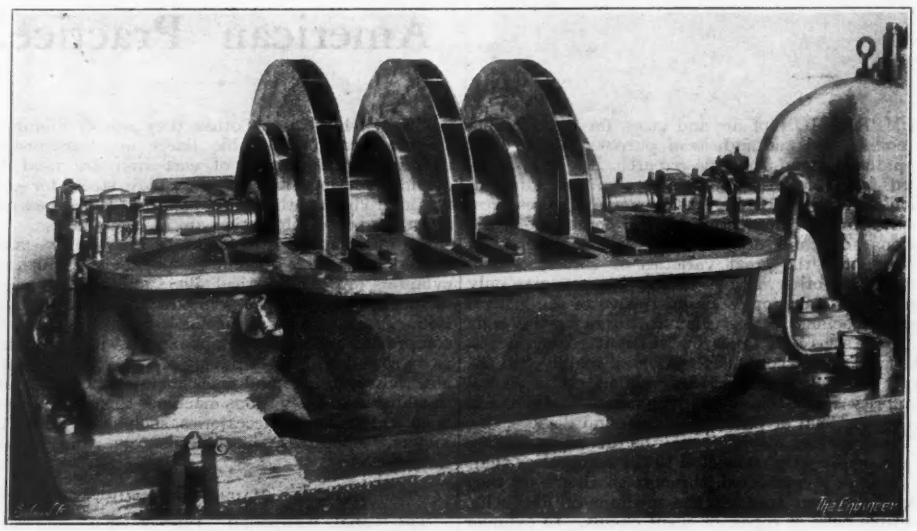


FIG. 75—THREE-STAGE TURBO-BLOWER—ALLIS-CHALMERS

series of impellers, the number depending upon the ultimate pressure required. From the first impeller the air is delivered to a diffusing chamber in which the pressure is increased, and from which it enters the next impeller. Fig. 75 shows the rotor of a three-stage turbo-blower, the upper half of the casing being removed. A blast-furnace four-stage turbo-blower driven by a condensing steam engine of 4600 H.P. is shown in Fig. 80, page xxvi. This machine runs at a speed of 3630 r.p.m., delivering 40,000 cubic feet at 30 lb. pressure.

In general, and especially for blowing blast-furnaces and Bessemer converters, as well as for handling gas, steam turbine drive is considered preferable, since the speed can be varied to suit conditions. Where electric motor drive is used some

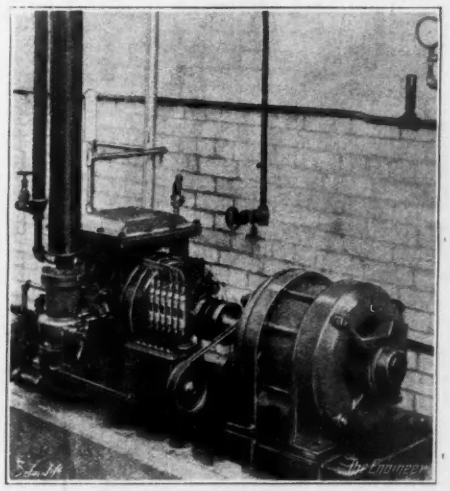


FIG. 76—ROTARY COMPRESSOR—ALLIS-CHALMERS

mechanical means must be provided at the blower to take care of variations in volume and pressure. These machines have been built in sizes up to 150,000 cubic feet per minute, and four or five stage blowers are commonly used at blast furnaces. For sludge aeration at sewage works requiring large volumes of clean air at pressures of 7 lb. to 10 lb., two-stage single-inlet blowers have been used in sizes up to 40,000 cubic feet per minute, and double-inlet for larger volumes.

Open-hearth or alloy steels, heat treated, are used for the impellers, with stainless steel in special cases. The blades are riveted to the hub disc and cover disc by means of studs or "rivets" formed on the edges of the blades. In the larger machines a thrust-balancing piston is applied on the shaft.

"Ro-Twin" two-stage compressor, which embodies the two stages in a single casing, and has the inter-cooler mounted on top. In Fig. 76 is shown a machine of this type, driven at 1160 revolutions by a direct-connected motor of 30 H.P., and having a capacity of 110 cubic feet per minute at 100 lb. discharge pressure.

WORTHINGTON PUMP AND MACHINERY CORPORATION.

Besides its large capacity of air and gas compressors of ordinary types, the Worthington Pump and Machinery Corporation, of Harrison, New Jersey, has given great attention to the development of high-pressure types for handling various kinds of special gases and for pressures as high as 15,000 lb. The latter are used principally for hydrogenation and liquefying gases. Among recent developments in machines of the more general types, four may be listed here: The gas-engined angle compressor; the vertical duplex double-acting machine for refrigeration; the two-stage, three-cylinder, air-cooled compressor for industrial and portable purposes, and the horizontal, duplex, steam-driven opposed type of compressor.

The angle compressor, with vertical gas engine and horizontal compressor cylinders, is designed as a self-contained unit of high operating economy where gas fuel is available. It is built with from one to four compressor cylinders on a single frame, and for either single-stage or double-stage compression. Two vertical engine cylinders with one horizontal double-acting compression cylinder operated from the crankshaft form a complete unit of 75 H.P. In Fig. 81, page xxvi is shown a 300 H.P. machine having four compression cylinders of three different sizes. Another installation consists of a group of 300 H.P. machines working on natural gas as fuel and compressing gas from 45 lb. pressure at intake to 350 lb. discharge pressure.

For refrigerating plants having large tonnage output, the vertical, duplex, double-acting compressor—Fig 79—was designed. With double-acting cylinders, the pistons are much smaller than for the single-acting system, thus reducing the reciprocating weights and permitting operation at high speeds without vibration. The cylinders are mounted on a frame or pedestal which encloses the working parts and forms an air-tight oil chamber. The crankshaft has roller bearings and forced-feed lubrication from a pump on the end of the shaft, while a two-stage packing on the shaft forms a seal against atmospheric air. With its automatic variable capacity control, one large unit is considered to be as flexible as a multi-machine installation.

A notable type of Worthington compressor of the larger class is the opposed steam-driven horizontal duplex machine, as shown in Fig. 82. In this design the piston-rod crossheads are connected by pairs of tie rods. Balanced piston valves have cut-off rods, all driven from a crankshaft at 870 revolutions. With belted or direct-connected motors the power is from 50 to 75 H.P., but Fig. 77 shows a complete or self-contained unit consisting of the compressor and an oil engine with multiple-belt drive.

A "feather" valve, said to be of exceptional simplicity, lightness, and efficiency, having no springs or cushion devices, is a feature of the Worthington compressors. Slots across the valve seat are covered by thin flat strips of steel, which are held in place by end stops, but are free to move vertically between guides. In opening, the middle of each valve strip rises, while the ends are held in contact with the seat, so that opening and closing consists only in

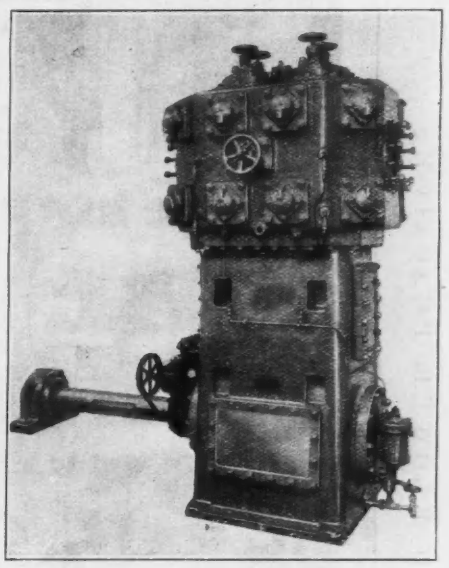


FIG. 79—REFRIGERATING COMPRESSOR —WORTHINGTON

this bending and flattening of the strips, or what is called a 'breathing" action, in which there is no slam or impact. Intake and discharge valves are identical. Valves for second and third-stage cylinders have rings of alloy steel covering circular ports, guided in movement by a guard plate and held down by helical springs of the same diameter as the rings.

Automatic variable capacity control is effected by a by-pass arrangement in which the unloading is accomplished by holding the steel strips of the suction valve in the open position, so that the air or gas passes in and out freely. Discharge pressure is admitted to the unloader cylinder by a separate

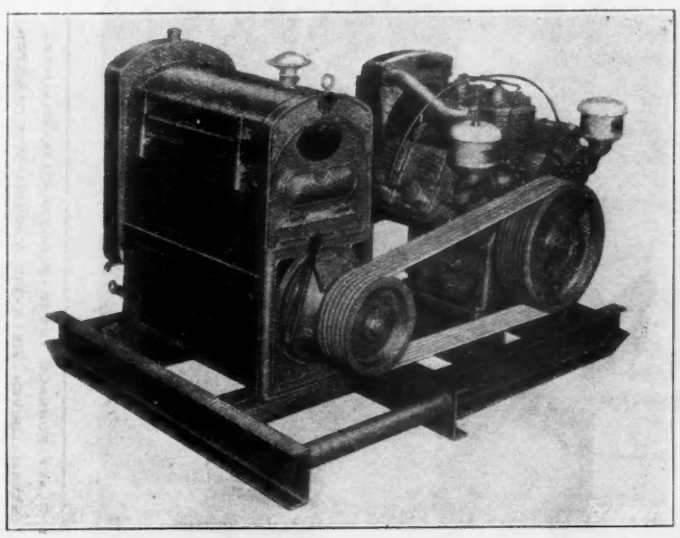


FIG. 77—OIL ENGINE-DRIVEN COMPRESSOR UNIT—WORTHINGTON

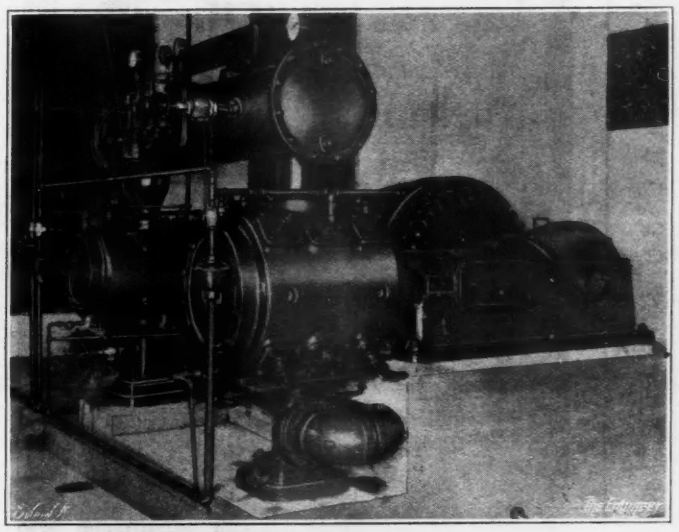
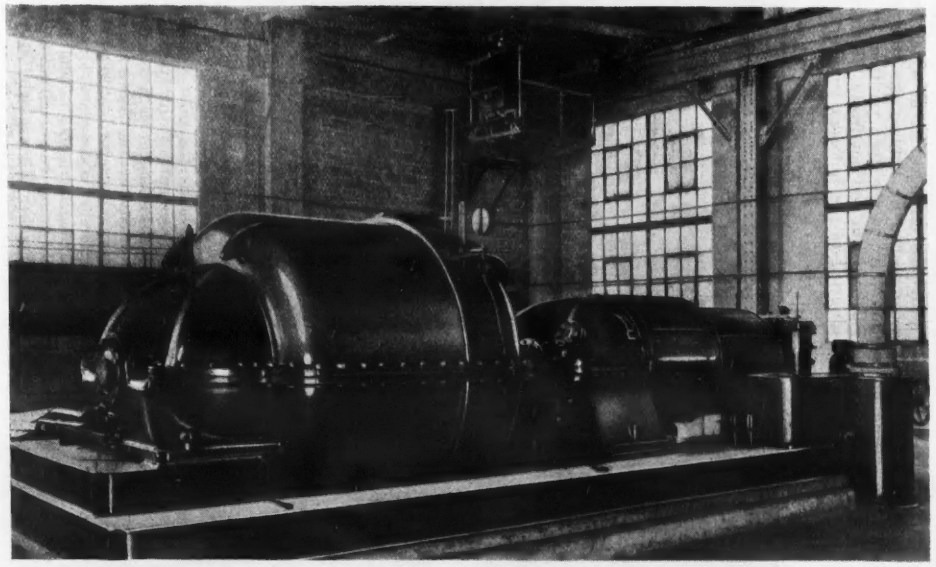


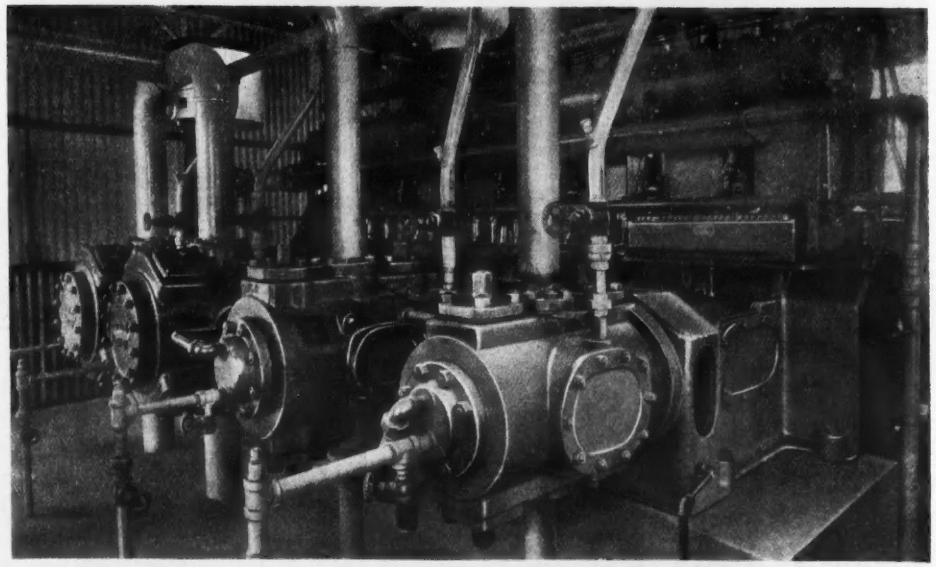
FIG. 78—TWO-STAGE HORIZONTAL MACHINE—GARDNER

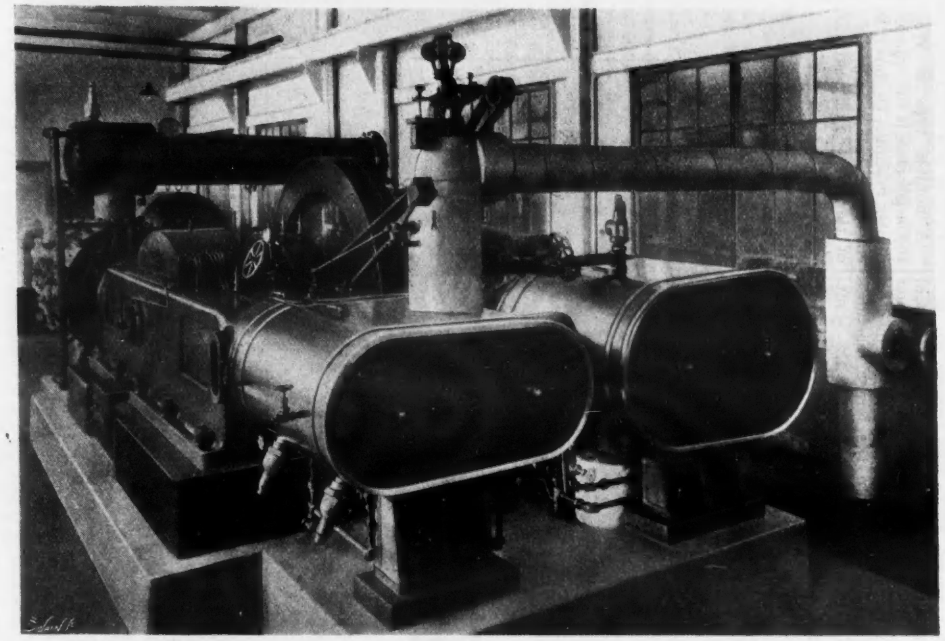
Movable blades are fitted in the diffusers, except where the machine is to handle gas-containing tar or other gummy, corrosive, or abrasive materials.

Rotary compressors of the sliding-vane type, as built by the Allis-Chalmers Company, range up to 125 H.P., with capacities up to 650 cubic feet per minute, and pressures up to 100 lb. In these machines a horizontal cylinder contains a solid rotor eccentrically placed and having along its face radial slots in which loose blades or vanes are set. As the rotor revolves at high speed, the vanes are thrown out so as to be in contact with the walls of the cylinder, thus forming a series of cells or compartments. Owing to the excentric placing, the volume of each cell diminishes as it passes from the inlet, thus compressing the enclosed air and forcing it out at the discharge. A development of this machine is the valves riding within them and adjusted automatically by the governor, the cut-off valve rod extending through the hollow rod of the main valve. The compression cylinders range from 15+9½in. by 12in. to 35+22in. by 30in., with displacements of 574 and 4150 cubic feet per minute respectively. Of a somewhat similar class are horizontal duplex machines driven by direct-connected motors at speeds ranging from 300 to 150 revolutions. Here the cylinder sizes are from 12+7½in. by 9in. to 39+23in. by 27in., with respective capacities of 350 to 5011 cubic feet per minute at altitudes up to 3000ft. above sea level.

Of a smaller but interesting class is a vertical two-stage compressor having six cylinders—two vertical high-pressure cylinders and four low-pressure cylinders in pairs inclined at 45 deg. on either side. They have trunk pistons and articulated connecting-control which holds the pilot valve piston against its seat. Movement of this piston compresses a spring and causes fingers to rise and hold the valve strips. Automatic action causes the unloader valves to open in sequence according to pressure variations. Typical sections of a compressor cylinder in Fig. 84 show the arrangement of the suction and discharge valves, the suction valve unloader device, and the clearance chamber valve, which last is also connected to an unloader. To hold open any suction valve or clearance valve air is piped to unloaders and controlled by a solenoid-operated valve in the pipe line. These solenoid valves are energised and de-energised through the governor, which responds to pressure variations and to time limits, this time control being a special feature. As the pressure changes, the governor instrument will move through its







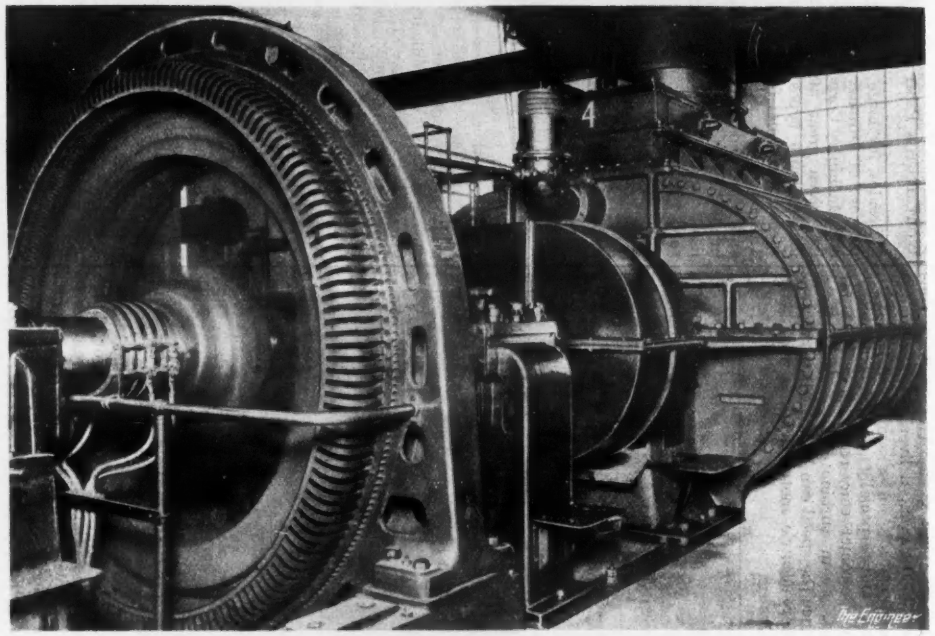


FIG. 80—BLAST FURNACE TURBO-BLOWER—ALLIS-CHALMERS

FIG. 81—GAS ENGINE AND COMPRESSOR UNIT—WORTHINGTON

FIG. 82—STEAM-DRIVEN VIS-A-VIS MACHINE—WORTHINGTON

FIG. 83—ROTARY BLOWER—ROOTS-CONNERSVILLE

several steps, operating one or more valves at each step.

ROOTS-CONNERSVILLE BLOWER CORPORATION.

Of a distinct type in rotary compressors are the positive-displacement machines commonly known as "Roots blowers," and manufactured in various modifications and sizes by the Roots-Connersville Blower Corporation, of Connersville, Indiana. In general design, as shown in Fig. 85, the blower consists of a pair of long interlocking involute impellers mounted on horizontal shafts in a casing or chamber of oval cross section. They revolve in opposite directions, but are so shaped as to maintain constant contact with each other and with the walls of the chamber. No internal lubrication is required,

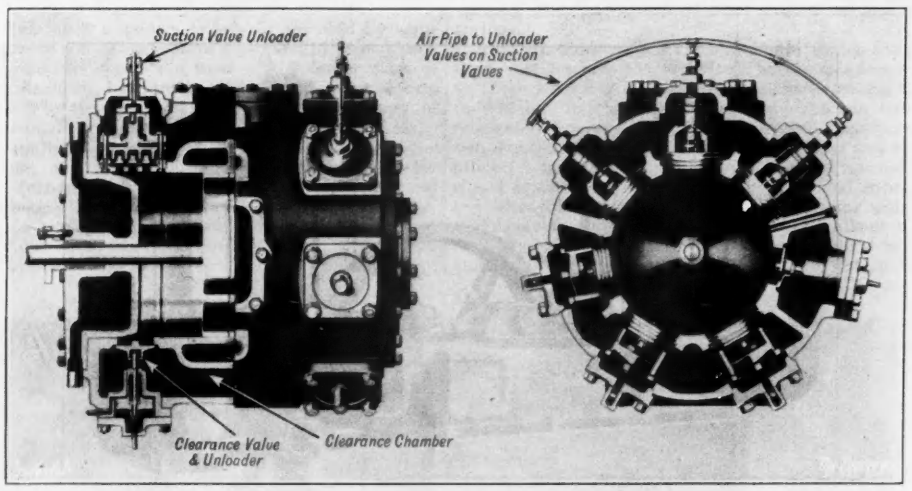


FIG. 84—SECTIONS THROUGH COMPRESSON CYLINDER—WORTHINGTON

as there is no actual contact of the metal surfaces, but the clearances are so small that no water or oil seal is required. For pressures over 10 lb. the impellers are of cycloidal form.

One of the impeller shafts is driven, either by direct-connected engine or motor, or by belt or chain connection, and the two shafts are connected by gears running in an oil chamber. Herringbone gears are used as a rule, but a special design known as the Wilkin compressor has multiple-contact gears, with relatively narrow and deep teeth, so that three or four pairs of teeth are in working contact at all times, thus distributing the load over a larger number or teeth. An infinitesimal yielding of each tooth at the instant of engagement eliminates shock and vibration. Calibration of these gears on a compressor of 200 H.P. after four years' service showed no measurable wear.

In the Wilkin compressor, also, the impellers —shown in Fig. 87—are of high inertia design, giving

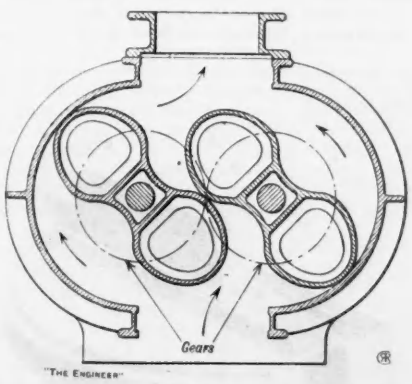


FIG. 85—SECTION THROUGH ROOTS BLOWER

a fly-wheel effect which produces uniform angular velocity of the rotating parts, with consequent quietness in operation and long life of the gearing. Shaft bearings are of sleeve or roller type, as desired. For handling gases, a special form of stuffing-box is used, being vented to the suction side of the chamber, so that the bearing has to be packed only against the suction pressure.

These compressors and blowers are applied for a variety of purposes, for cupolas and furnaces, oil and gas burners, supercharging and scavenging of oil engines, agitation and aeration of liquid —as at chemical works, ice manufacturing plants, and sewage works, and also for gasworks and such metallurgical work as pneumatic flotation. Many of them are used as gas compressors. A blower driven by a direct-connected motor of 675 H.P. at the activated sludge plant of the sewage works at the City of Peoria, is shown in Fig. 83 opposite, delivering 5500 cubic feet per minute against 8½ lb. pressure. A somewhat similar installation, but operated as an exhauster and driven by a horizontal steam engine is shown in Fig. 86. For ventilating the headings in the construction of the long Hetch Hetchy tunnel for the water supply of San Francisco, four Roots blowers were installed, to blow out the smoke and gases quickly after blasting and to fill the headings with fresh air.

An interesting application of these Roots blowers is as large meters at gasworks and blast-furnaces, measuring the gas delivered to pipe lines, boiler furnaces, &c. Here the gas drives the impellers by its pressure, as it passes downward through the chamber. The surfaces of the impellers and the chamber are carefully machined to ensure maintenance of a high degree of accuracy, and the capacity is calibrated. Gears are provided at both ends of the impeller shafts to ensure unison of action, and a counter on one shaft converts revolutions into readings of cubic feet. These meters have been applied with capacities of 1,003,000 cubic feet per hour against 25 lb. line pressure, and 11,200,000 cubic feet for pressures as high as 125 lb., although special machines have been built for 300 lb. pressure.

GARDNER-DENVER COMPANY.

Horizontal, duplex, single-stage and two-stage compressors, with direct-connected synchronous motors, form the larger class of machines built by the Gardner-Denver Company, of Quincy, Illinois. In piston displacement they range from 348 to 967 cubic feet per minute—or 400 to 1085 cubic feet per minute for altitudes of 5000ft. or more. The cylinders are from 12+7½in. by 8in. to 19+11in. by 12in., and the speeds vary from 335 revolutions in the smaller to 277 in the larger machines. A motor-driven machine of 600 cubic feet per minute capacity shown in Fig. 78, is for sand blasting at a large foundry. Smaller single-cylinder compressors are also built.

Splash lubrication is provided in the crank case, the shaft having collars to prevent oil from leaking along it. Roller bearings are used on the shaft. The cylinders are of nickel-alloy cast iron, with the valves arranged radially at each end. Both inlet and discharge valves are of the maker's duo-plate, automatic air-cushioned type; they are double-ported, so that air moves in and out from both the inside and outside circumference. Low-pressure valves are of the triple-plate type. Chromium-vanadium steel is used for the valves. Automatic start-and-stop control devices may be applied, or a dual control in which either automatic start or constant pressure control may be selected. Special control provides for stopping the compressor in case of failure of cooling water circulation or other emergency.

Since the motor is a constant-speed machine, the inlet valves are fitted with an unloader, which acts by holding open these valves on both cylinders. Behind each valve is a small cylinder having a plunger with fingers which extend through the ports in the valve seat. When the receiver pressure reaches the limit for which the pilot valve is set, the air from this valve moves the plunger forward against its spring tension, thus lifting the air valves from their seats and holding them open, so that air can flow freely in and out of the cylinder. These compressors have normally a three-step control for full and half capacity, and no load. It is effected by using two electric or pneumatic pilot valves, connected to the air valves at opposite ends of the cylinders, and having one set at slightly higher pressure than the other, so as to follow it in action. For large compressors a five-step magnetic control may be used in order to average the electrical load and avoid undue fluctuations. It acts on valves which regulate the capacity of two clearance pockets at each end of the cylinders. Indicator lights show whether the machine is operating at full load, no load, or 75, 50, or 25 per cent. of load.

A horizontal steam-driven type of two-stage compressor of 20 to 175 H.P., with steam and air

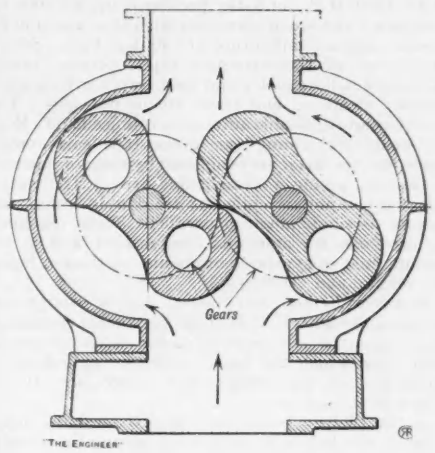


FIG. 87—HIGH INERTIA ROOTS IMPELLERS

cylinders in tandem, as built by this same company, has a discharge capacity of 67 to 980 cubic feet per minute at maximum pressures from 350 lb. to 100 lb. The steam cylinders are from 6in. to 12in. diameter, and air cylinders 6+3in. by 6in., to 20+12in. by 12in. All are semi-steel of sufficient thickness for reboring. No shaft excentrics are used, the steam valves being driven from a pin in the governor pulley.

In line with many other manufacturers, the Gardner-Denver Company includes a range of compressors with 60 deg. V type cylinder arrangement and driven by direct-connected petrol or oil engine or electric motor, or by multiple-belt connection. A six-cylinder water-cooled machine with grooved pulley for multiple-belt drive is shown in Fig. 88. These machines are of the two-stage type, with four or six cylinders—two or three low-pressure and two or three high-pressure. The compressor illustrated has cylinders 9¾+6in. by 7in., and a displacement of 790 cubic feet per minute at 870 revolutions. At the top right is the air filter, and at the left is the receiver. In a smaller machine of the same class there are two low-pressure cylinders set at 45 deg. from a vertical high-pressure cylinder. They are

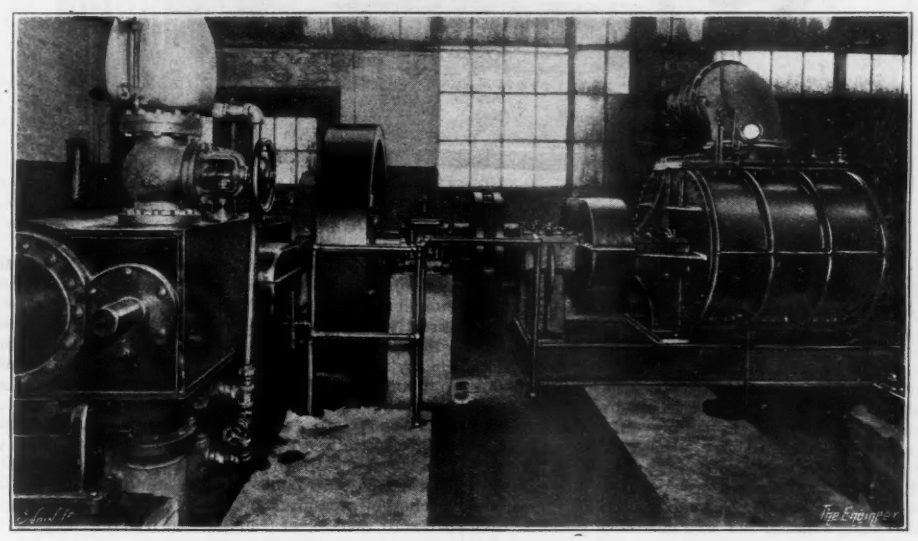


FIG. 86—STEAM-DRIVEN CYCLOIDAL BLOWER—ROOTS-CONNERSVILLE

made in three-cylinder and six-cylinder units, either belted or driven by direct-connected motors of 25 to 75 H.P. Compressors of this type are much used for such service as tunnel and other construction work, mining, and for night work at factories where the demand is then too light for economical running of the main compressor.

INGERSOLL-RAND COMPANY.

A wide range of compressors for air, gases, and ammonia, for various capacities, and for discharge pressures up to 5000 lb., with a power range up to 3000 H.P., or 12,000 H.P. for turbo-blowers, is produced by the Ingersoll-Rand Company, of New York, which company is not only one of the largest manufacturers of compressors, but also of a large and varied line of pneumatic machines, tools, and appliances. To provide for economical size and type of unit for any conditions, for each type there is a standard series of running gears, with interchangeable compressor cylinders. Thus each frame and running gear can be loaded for efficient operation at desired pressure by equipping it with cylinders built for that pressure. Change of cylinders to meet changed conditions is also practicable. Besides these standardised designs, many compressors are built to meet specific conditions or for particular installations.

One of the largest types is a "four corner" steam-driven, horizontal, double-acting, opposed machine, shown in Fig. 89. This design is built in sizes of 50 to 1500 H.P., and for pressures up to 5000 lb. Some machines are in operation with steam at 450 lb. pressure and a temperature of 750 deg. Fah. Steam valve gear of the excentric type operates piston valves of small diameter and long travel, giving small cylinder clearance and short steam passages. The valve has an adjustable automatic riding cut-off. Both the steam and compressor piston-rods carry cross-heads, and the latter are connected by a pair of side rods or tie rods, giving a straight-line drive. The water-jacketed compressor cylinders are double acting, and operate as single stage in parallel. These machines are used also for ammonia compression, and in the manufacture of synthetic ammonia, methanol, liquid air, helium, and other gases.

A motor-driven, four-corner, duplex compressor in sizes up to 3000 H.P. is of the horizontal crosshead-drive type, the synchronous motor driving a crank-shaft from which the four compressor cylinders are operated. In the larger sizes there are duplex cylinders at each end.

In the plate type of air valve as used for many years on the Ingersoll-Rand compressors, the circular valve seat has two concentric ports, and the valve is a thin disc with concentric slots. This disc is held down by three small coiled springs fitted into sockets in an upper plate. The whole assembly is held together by a centre bolt, putting the springs into compression. A more recent design is the channel valve in which the circular seat has four parallel slots, and a raised portion or stop across the ends of the slots. Over each slot—Fig. 90—is placed a channel-shaped strip of stainless steel C, flanges upward, held in place at the ends by the stops on the valve seat. Within each channel rests a thin spring plate B of steel, cambered so that normally only its ends rest on the channel. Upon this assembly rests a slotted stop plate A whose bars bear on the valve springs, and which is held down by a guard on the rim, no centre bolt being used. As the channels lift by pressure and flatten the springs, air is trapped under the latter forming an air cushion to prevent impact. This design is designed to give a large effective area of opening and an easy action.

Regulation of compressor output is effected by a five-step clearance control system. Each end of the compressor cylinder has two clearance pockets, each with a small piston valve to open or close the pocket connection with the cylinder. When a valve is open the pocket capacity is added to that of the cylinder volume. When both valves at one end are open, no air is drawn in at that end. After the trapped air is compressed it re-expands, cushioning the piston. These valves are operated by receiver pressure. At full load they are all closed, so that the cylinder takes in and discharges its full capacity. With the load fallen to 75 per cent., one valve opens in each cylinder, followed by others as the load decreases, until with no load all the valves are open and no air is compressed.

A petrol-engined type of Ingersoll-Rand compressor of 75 to 300 H.P. has a vertical V type, four-cycle engine of two to eight cylinders driving on a crankshaft from which one to four horizontal compressor cylinders are driven, each horizontal cylinder being in line with its pair of inclined engine cylinders, with connecting-rod drive. This machine is built for pressures as high as 5000 lb. Another vertical type of compressor is also made, as a single-acting, two-stage, motor-compressor unit of 15 to 75 H.P. and for discharge pressures up to 125 lb. This machine is made with either three or six cylinders, the high-pressure cylinder being vertical and above the crankshaft, with the low-pressure cylinders set at 45 deg. on each side.

Centrifugal blowers of two types are built by the Ingersoll-Rand Company. A single-stage machine, with built-in electric motor up to 125 H.P., and for pressures up to 5 lb., is used for cupolas, furnaces, tunnel ventilation, and other purposes. The motor is directly connected to the shaft of a shrouded impeller, which delivers the air to a diffuser in which velocity energy is converted into pressure. For blast-furnace and converter blowing, gasworks, furnaces and other purposes, there are multi-stage blowers having as many as six stages and capacities of 110,000 c.f.m., with electric motor or steam turbine drive. One of these turbine driven-compressors, shown in Fig. 91, is rated at 8000 cubic feet per minute, with 100 lb. discharge pressure, and the turbine takes high-pressure steam, at 150 lb., and 100 deg. superheat exhausting to 28in. vacuum.

In an automatic booster for gas plants where natural gas under pressure is mixed with coal gas, the power produced by expansion of the former is utilised to compress the latter, the mixture being controlled automatically to the desired B.Th.U. value. A recent development is a pipe line centrifugal booster in which both the motor and booster are enclosed in an air-tight shell or casing to eliminate leakage. Still another feature is a regenerative device termed a "power wheel" which can be built into constant-speed units to save power under varying pressure and capacity.

NORWALK COMPANY.

A special design of high-pressure compressor for handling not only air, but also oxygen, hydrogen, helium, ethelyne, natural gas, and other gases, is made as a series of horizontal tandem, four-stage, belt-driven machines by the Norwalk Company, of South Norwalk, Connecticut, for pressures of 2000 lb. to 5000 lb. per square inch. The stages of compression are so arranged that two stages are compressing on each stroke; leakage is prevented by a dead space between the cylinders connected with the intake. The first and second stages are in the main cylinder shell, the first stage being single-acting and compressing against the cylinder head. The second stage, also compressing on the forward stroke, is in an annular space formed around the trunk piston by the enlargement of the cylinder, this being the difference in diameter between the two stages.

In the larger sizes the back head of the main cylinder contains the third-stage cylinder, and has the fourth-stage cylinder bolted to it in tandem. In the smaller sizes, however, the back head of the main cylinder forms a shell containing both the third and fourth stages. In both cases the third-stage cylinder extends into the open end of the trunk piston for the first and second stages, thus giving a compact tandem arrangement. A hardened bushing in the head of the fourth-stage cylinder avoids the replacing of gaskets at the point of maximum pressure. These two cylinders, each single-acting, compress in the same direction, opposing the first two cylinders and making a balanced unit.

Valves for the first and second stages consist of two grid plates with annular recesses for lightweight ring plates. Each plate or ring is held down by a single-coiled spring of the same diameter as the ring.

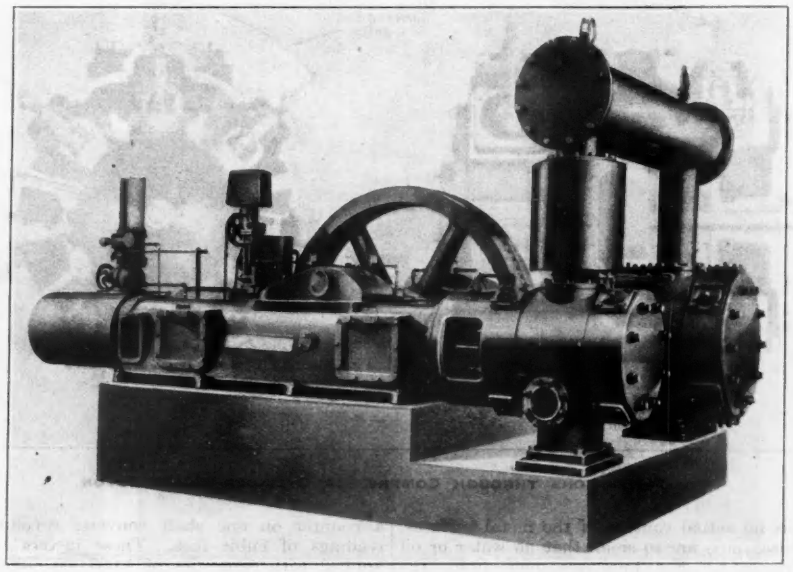


FIG. 89—FOUR CORNER STEAM-DRIVEN COMPRESSOR—INGERSOLL

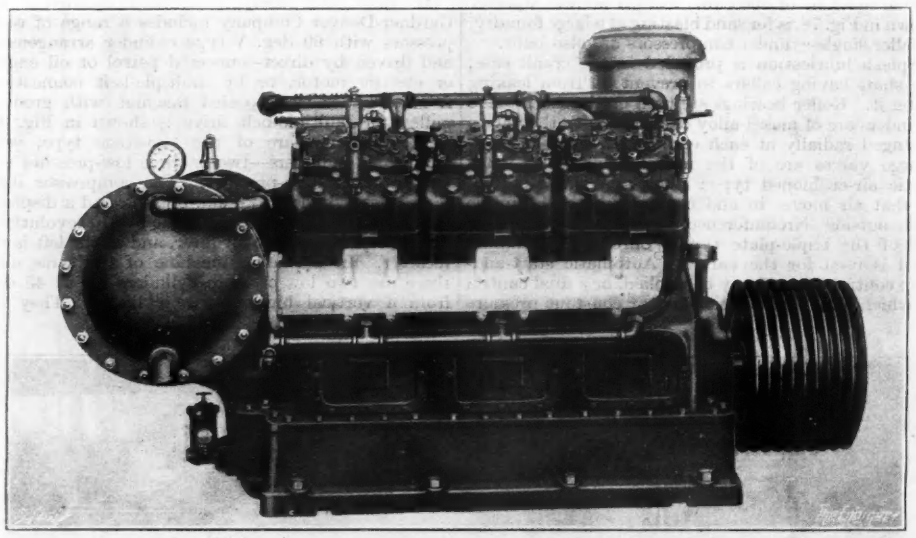


FIG. 88—VERTICAL "VEE" COMPRESSOR—GARDNER-DENVER

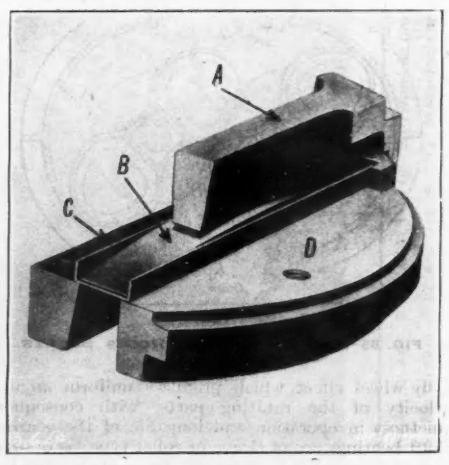


FIG. 90—"CHANNEL" VALVE—INGERSOLL

In the earlier designs a set of three small coiled springs held each ring. A stud holding the assemblage together prevents any leakage, such as might occur with a through-bolt fastening. A yoke held down by a centre bolt seated upon it, keeps the assembled valve firmly in place against the seat gasket of the cylinder. For the high-pressure valves of the third and fourth stages, a single valve disc is used. A tubular intercooler is mounted over the main cylinder. High-pressure intercoolers and an aftercooler consist of coils in water tanks.

Four-stage and three-stage vertical compressors are also built by the Norwalk Company for high pressures, as well as two, three, and four-stage horizontal machines for motor, steam, or belt drive, and special machines for refrigerating, liquid air, and solid carbon-dioxide works.

De Laval Steam Turbine Company.

While open impellers or wheels are used by some makers of centrifugal compressors and blowers, closed or shrouded wheels are used in the larger class of such machines, both turbine driven and motor driven, as built by the De Laval Steam Turbine Company, of Trenton, New Jersey. They are of the single-stage and multi-stage types, up to 50,000 cubic feet per minute, and for pressures up to 125 lb., used for blast-furnace blowers, as well as for blowers and exhausters in gasworks and coke oven gasworks. Recent typical machines are a turbo-driven blower of 90,000 cubic feet per minute at 35 lb. pressure for the blast-furnace at the Great Lakes Steel Works; up to 125 lb. Steam valves are of the inside admission piston type, with double excentric valve gear. Cut-off valves riding within the main valve have an automatic cut-off governor. The discharge pressure acts against a diaphragm whose movement is transmitted to a pilot valve admitting water to one side of a double-acting piston. As the piston-rod moves up or down, it operates a chain connection on the cut-off valve-rod, revolving it so that the valve position is varied by right and left-hand threads on the rod. On cross-compound machines, only the high-pressure valve is geared to the cut-off governor in this way.

Compression and steam cylinders are all made thick enough to permit of twice reboring, and air valves of the poppet type are located radially so that the cylinder heads can be water jacketed. The "Simplate" valve used by this company consists of concentric flat steel rings over annular ports, the rings opening the ports against the tension of helical springs.

A different design is a vertical duplex centre crank type, direct connected or bolted, with capacities up to 2345 cubic feet per minute and for pressures up to 500 lb. In the larger sizes the cylinders have renewable liners. For constant-speed regulation, two regulators are applied, one for half load and the other for no load. The unloader valve is normally closed against receiver pressure by a helical spring, but when discharge pressure exceeds that for which the receiver is set, the valve opens and allows air from the receiver to flow to the compressor's inlet valves. Motor-driven machines have an automatic

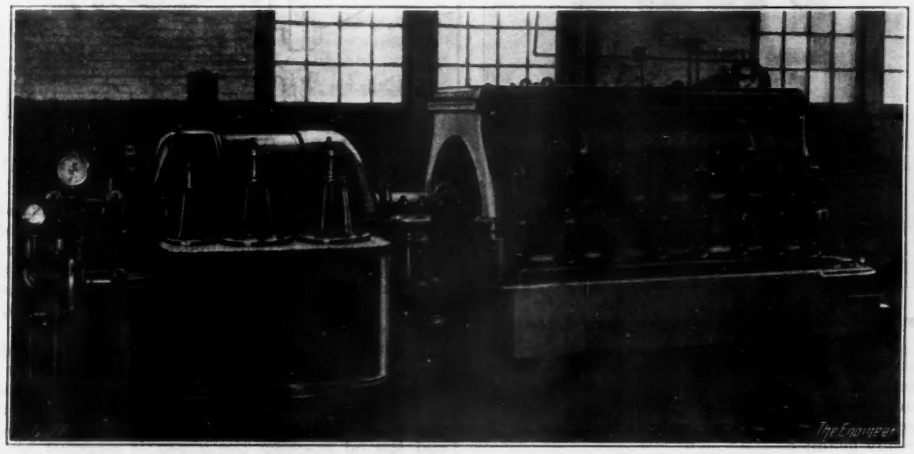


FIG. 91—TURBINE-DRIVEN TURBO-COMPRESSOR—INGERSOLL

three motor-driven units of 16,500 cubic feet per minute each, at 7 lb. pressure, for the activated sludge plant at the Baltimore sewage works; and a 25,000 cubic feet per minute unit, 3 lb. pressure, for the scavenging of Diesel oil engines at the Sun Shipbuilding Company's yards.

All the impellers are shrouded, built of a solid disc and a flat ring, with the blades or vanes between them. For the single-stage machines, a double wheel is used, formed by a central disc and two side plates or rings, with blades in the two spaces and a suction inlet on each side of the casing, as shown in Fig. 92. Multi-stage machines, however, have single impellers. Peripheral speeds range from 450ft. to 650ft. per minute. Discs and rings are of chrome-nickel steel, and the blades are die forged from alloy steel plates. For gas blowers the entrance edges of the blades are set at such an angle as to receive the gas without shock.

Large units, and those in which economy of steam consumption is important, are driven by the De Laval pressure-stage turbine, which is of the impulse type and built in sizes up to 15,000 H.P. But for small units, and where high steam economy is not essential—as where exhaust steam can be utilised—the velocity-stage turbine is preferred. Compressors for low pressure may be driven by direct-connected motors, but with higher pressures a speed-increasing gear of the helical type may be introduced. To increase the transmission capacity of gas mains or to reduce size and cost of new long-distance mains, higher gas pressures are effected by the use of large multi-stage compressors driven by steam turbines or variable-speed motors.

Chicago Pneumatic Tool Company.

Horizontal duplex compressors with a motor on the crankshaft, or driven in tandem with simple or compound steam ends and side cranks, are built by the Chicago Pneumatic Tool Company in sizes of 400 to 7000 cubic feet per minute, and for pressures start-and-stop control, by which the compressor is left without load when stopped, and compression is delayed until the motor has reached its full-load speed. A vertical tubular intercooler arrangement is unusual in that it forms an integral part of the two-stage unit.

Compressor Accessories.

Besides such equipment as intercoolers and after-coolers, which are practically integral parts of a compressor installation, there are numerous devices and appliances used as accessories, such as air filters and meters, silencers, separators, &c. Of special importance are the air filters, excluding dust and dirt from the intakes. In the extensively used filters of the Air-Maze Corporation, of Cleveland, the filtering element is a cylinder composed of concentric layers of galvanised or nickel-plated wire mesh, increasing in density towards the interior, so as to give a high degree of cleaning efficiency. These filters are made in capacities up to 550 cubic feet per minute for the "Unimaze" and 4000 cubic feet per minute for the "Multimaze" type, the latter approximately 36in. by 30in., for an 18in. intake; but for larger capacities two or more filters are mounted on a box enclosing the intake.

Air enters the annular space under the cover, Fig. 93, and passes down between the casing and skirt to the oil bath, with baffles, from which it rises to the annular space around the filter element, and passes through this to a central chamber over the intake pipe. A relief valve takes up the pulsating action which is sometimes set up in large compressors and might cause sufficient back pressure to throw oil out of the bath. Interchangeable filter cells are the speciality of the devices of the American Air Filter Company, of Louisville, and these include both dry cells and viscous impingement cells. Continuous strands of galvanised crimped wire are so packed as to give an increasing density. Outdoor installations are protected by louvres to exclude rain, snow, and dust. For material which is difficult to wash out of the air, and for heavy concentration of dust—as in districts subject to dust storms—the filters have felt gloves or flat bags slipped over a spacing frame which holds them open. A combination filter and trap to separate dust and entrained oil and moisture from compressed air pipe lines is made in capacities up to 600 cubic feet per minute and for pressures up to 125 lb.

For compressor intakes of more than 3000 cubic feet per minute, a speciality is a self-cleaning filter having a revolving curtain composed of horizontal filter panels. This curtain is moved one panel height at a time on its top and bottom rollers either by a hand crank or automatically by a motor of ¼ H.P.

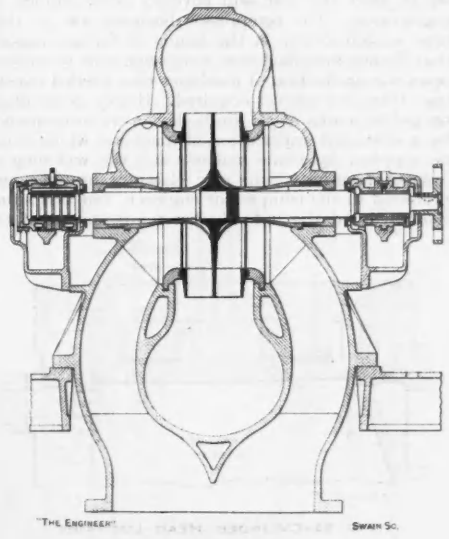


FIG. 92—SINGLE-STAGE BLOWER—DE LAVAL

The bottom unit, in operation, is flat, with face downward; the next move turns it up on edge, and the next panel takes its place. In the "Protecto-motor" filter of the Staynew Filter Corporation, of Rochester, New York, vertical radial hollow fins extending from a central chamber give large filtering area. They are made of screen wire mesh covered with removable sleeves of felt. A combined silencer and filter causes the air to enter through a series of tubes, which thus damp out all reverberations.

Another filter using gloves or sleeves of special felt fitted over distenders is that of the Coppus Engineering Corporation, of Worcester, Massachusetts. For cleaning the air in pipe lines, so as to deliver clean, dry air to the tools or appliances, the

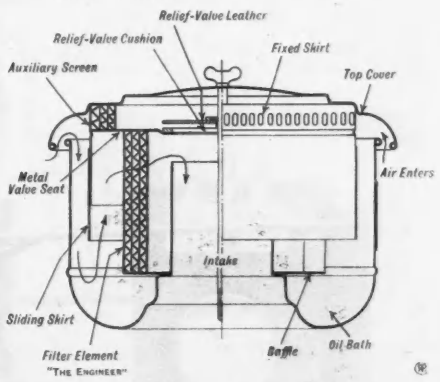


FIG. 93—AIR FILTER—AIR-MAZE

"Dri-Air" separator made by the New Jersey Meter Company, of Plainfield, New Jersey, not only ejects oil and condensed moisture, but collects any rust, scale, and dirt. It is made in small sizes for placing on branch lines at such distance from the compressor as to ensure that the air has cooled and any vapour condensed. This company also makes a meter which shows the flow of air—in cubic feet per minute—in a pipe or hose supplying a tool or machine, and also measures the amount of air used. In all air filters, of course, the purpose is to have a minimum restriction to the air delivery or passage, and a maximum removal of dust, grit, and moisture. This combination is aimed at in different ways by the various makers of these appliances.

Continental Practice.

IN this section of this Supplement we describe under the headings of the countries of origin a number of machines made by manufacturers on the Continent of Europe.

FRANCE.

The construction of air and gas compressors in France followed upon the industrial expansion that set in after the war and covered every branch of engineering. The compressor business was at that time so completely in the hands of foreign makers that French manufacturers took some time to embark upon the production of machines that needed experience they had not yet acquired. Heavy expenditure on public works of all kinds, however, accompanied by a restricted importation of machines which could be supplied by home makers, and the widening of industrial activity into new channels brought new problems to the compressor engineer, and this situation favoured the individualist temperament of the

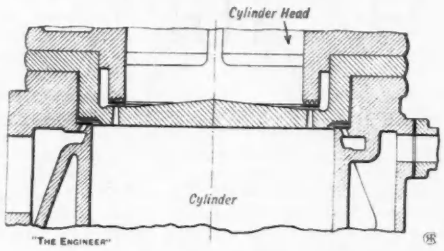


FIG. 94—CYLINDER HEAD—LUCHAIRE

French, allied to an imagination that encouraged the application of new ideas to mechanical improvements. The fact that French compressor engineers work out problems in their own way implies that their productions will always be marked with a distinctive national character.

Low-pressure Compressors.

The use of compressed air has been encouraged by an experience of nearly half a century in Paris, which is the only city in the world to possess a complete compressed air distribution. About forty-five years ago the Compagnie Parisienne de l'Air Comprimé took over the distribution system that had been initiated and developed during the previous ten years by the Austrian engineer, Victor Popp, and immediately after the war the installations were transformed with seven Babcock and Wilcox steam generators and five Brown-Boveri turbo-compressors in the principal station, and with two electrically driven compressors in the smaller station, which serves to carry the peak load. These plants are capable of delivering a total of 2800 cubic metres of free air a minute into the mains at a pressure of 73·5 lb. per square inch. Such a wide distribution is only economically possible by carrying mains in the sewers, except for a small number of sections. The enterprise is successful, despite the competition that was expected from the electricity supply. The efficiency of compressed air distribution admittedly compares

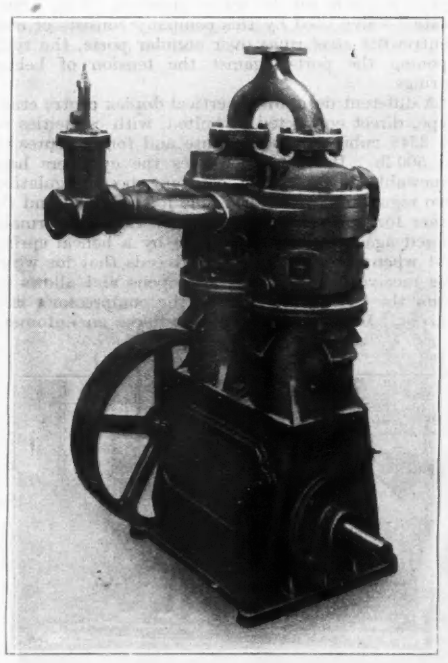


FIG. 95—SINGLE-STAGE COMPRESSOR—LUCHAIRE

unfavourably with that of electricity, but it is economical for intermittent work, and is, moreover, convenient and safe, which are qualities that give a preference to compressed air in industrial areas where it is already installed.

Small and medium air compressors are more or less to orthodox designs and offer little of technical interest. There are, nevertheless, some departures from ordinary practice, notably in the vertical single-stage compressors manufactured by the Etablissements Luchaire, 171, Boulevard Haussmann, Paris, the special feature of which is the valve design. As will be seen in Fig. 94, the cylinder head is in two parts, consisting of a dished flanged casting with the discharge orifices, fitting into the cylinder and covered by the upper water jacketed head, which has an annular extension to within 3 mm. of a series of orifices in the bottom of the intermediate plate. In this space is housed a light flexible flat steel ring 8/10 mm. thick, centred laterally by studs in the cylinder wall. The bottom of the head projection is grooved to form a serrated cross section in order to prevent the ring from sticking. In the same way the underside of the intermediate plate is grooved near the circumference to cover a similar ring over orifices in the cylinder communicating with the suction pipe. The satisfactory working of these light rings requires the use of a suitable oil and an air filter. An advantage of this type of valve is an absence of inertia and the use of orifices that avoid wire-drawing effect

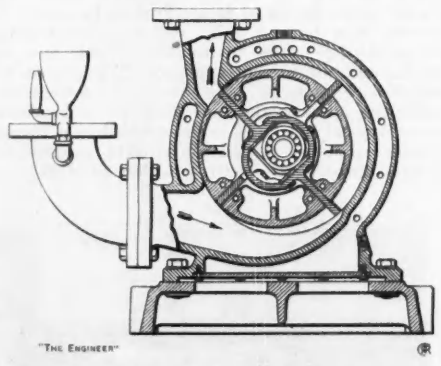


FIG. 96—ROTARY MACHINE—BAUDOT-HARDOLL

and suppress dead space in the cylinder. It is equally efficient for compression and vacuum. The compressors have one or two cylinders, the maximum pressure for all sizes being 113 lb. per square inch, and the maximum volume discharged at 300 revolutions a minute by the largest size, illustrated in Fig. 95, is 22,250 cubic feet an hour. It will give a vacuum of 720 mm. to 740 mm. of mercury, and, by double staging the cylinders, it is declared to be capable of giving 757 mm. The cylinders have a bore of 300 mm. and the piston stroke is 250 mm. The bottom of the crank chamber contains oil for splash lubrication, and the oil reaching the piston is returned by an annular collector in the cylinder to the bearings. In addition to water cooling, the suction valve is cooled by air through the annular chamber connecting the orifices. The machine illustrated absorbs 78 H.P. when compressing to 100 lb. per square inch.

Various methods of mechanically operating the blades of rotary machines have been devised, with indifferent results, largely through lack of balance. A satisfactory solution of the problem appears to have been reached by the Société Baudot-Hardoll, 95, Boulevard de Port Royal, Paris. In its rotary com-

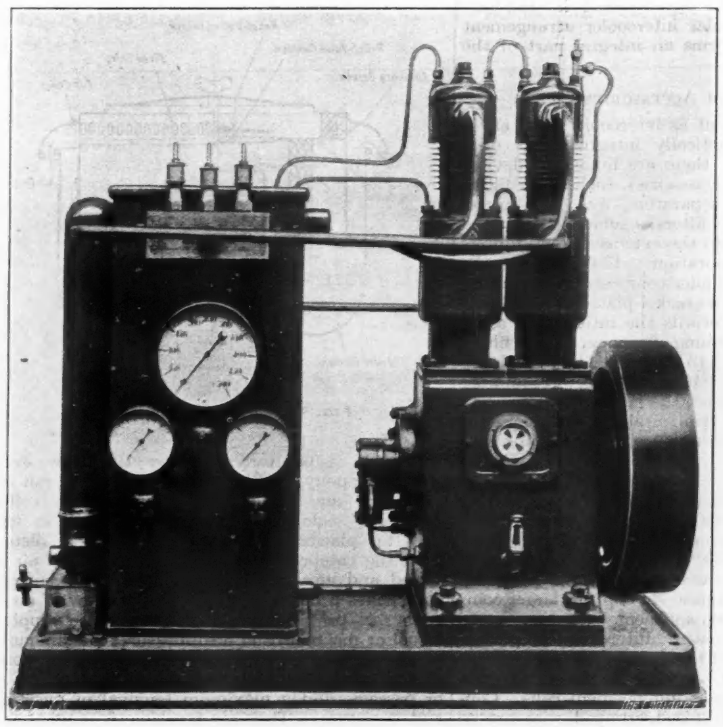


FIG. 97—THREE-STAGE COMPRESSOR—LUCHARD

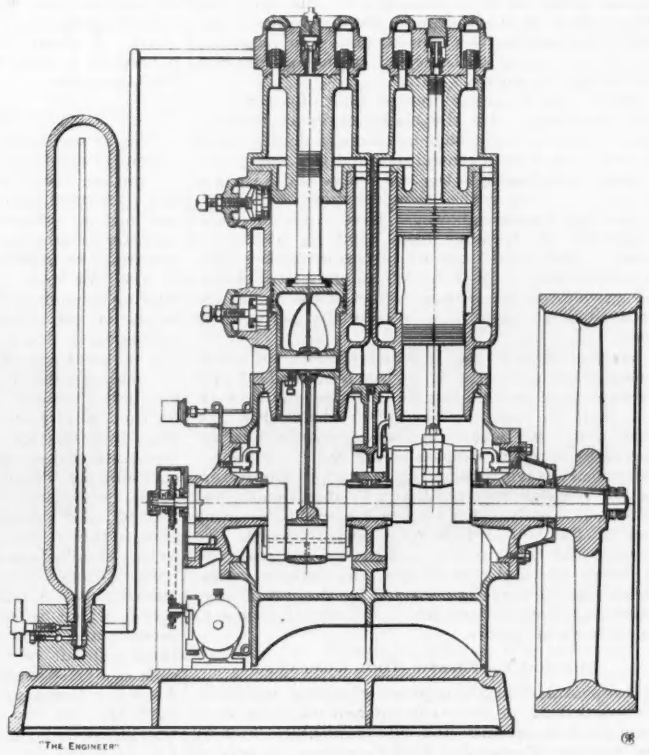


FIG. 98—SECTION THROUGH FOUR-STAGE MACHINE—LUCHARD

pressor there are two composite blades having lengths equal to the diameter of the stator bore. Each one is built up with two blades having the length of the smaller radius, joined to a flattened ring or link, which is at right angles to the axis of the blades and allows of a displacement within the link of double the amount of excentricity. There can be only two of these composite blades at right angles. In the smaller machines the rotor is driven and carries the blades, and in the bigger ones the blades are driven and carry round the rotor. In either case the links slide on the central shaft. The working will be understood from Fig. 96. In compressors with a delivery of 7000 cubic feet an hour and less, the blades are carried on an arbor bolted to the centre of the cover through roller bearings within the links. These links have parallel inside bearing surfaces. In the bigger machines a shaft through the centre has a square driving plate with roller bearings at the corners. These bearings are on each side of a rectangular guide attached to the link through which passes the shaft. The driving of the shaft rotates the blades which oscillate between the roller bearings and carry round the rotor mounted excentrically on roller bearings in the body of the compressor. There is said to be no end pressure, and consequently no friction, and the compressor is in perfect balance.

Luchard Compressors.

The works at Nanterre (Seine) of the Compresseurs Luchard, 20, Rue Pergolèse, Paris, are employed exclusively upon the production of air and gas compressors of all outputs up to a six-stage machine delivering 14,000 cubic feet an hour at a maximum pressure of 3550 lb. per square inch. They are all of the vertical type. Some of the smaller units have the upper cylinders cast with radiating ribs to assist

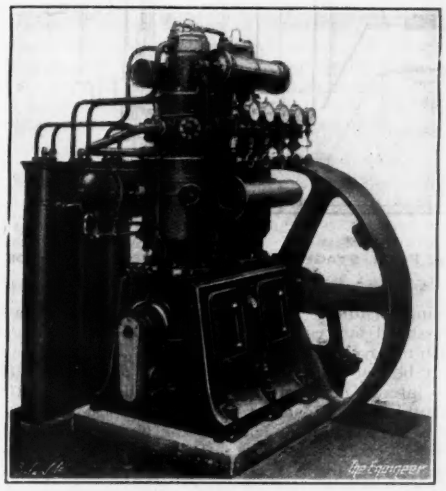


FIG. 99—FIVE-STAGE COMPRESSOR—LUCHARD

water cooling, as is seen in the three-stage machine delivering 580 cubic feet an hour under a pressure of 2840 lb. per square inch, Fig. 97. The two lower cylinders are the first-stage and the upper cylinders the second and third stages. There are, of course, intercoolers and a final cooler after discharge. The sectional drawing, Fig. 98, of a four-stage compressor explains the construction of several series of machines having from four to six stages, with maximum pressures ranging from 2800 lb. to 4300 lb. per square inch. The compressor represented by this drawing delivers 2540 cubic feet an hour at a normal speed of 300 revolutions a minute. The two lower cylinders have bores of 150 mm. and 125 mm., and the upper cylinders 48 mm. and 30 mm. The upper pistons are of cast iron, with their ends jointed to the lower pistons. The spherical ends are recessed in the lower pistons and are retained by screwed plugs bearing against shoulders with sufficient side play to provide flexibility without end play. In the smaller machines the valves of the lower cylinders are generally accurately ground discs, held by light springs and retained by covers with adjusting bolts, and accessibility and ease of valve removal are equally obtained in the heads of the final stage cylinders, where the valves are of a very light plunger type held up or down for induction or discharge by light spring pressure. The valve, valve seatings, springs, and covers are unscrewed and removed in one piece.

The general principles of construction shown by the drawing are used in the bigger machine illustrated in Fig. 99, which has been adapted for the compression of town gas. This latter is a five-stage machine, with cylinder bores of 300 mm., 190 mm., 110 mm., 60 mm., and 35 mm. The stages are, the first in the two lower cylinders, the second and third in the intermediate cylinders, and the fourth and fifth in the upper cylinders. Where the diameter of a piston is too small to admit of piston rings, it is turned for the greater part of its length with grooves of about 4/10 mm., and is adjusted for a sliding fit in the cylinder. This is the case with machines constructed by the Luchard Company for a final pressure of 15,000 lb. per square inch, of which the fourth stage piston has a diameter of 8 mm. While the grooves ensure good lubrication they provide oil joints against the highest practical pressures. Referring again to the five-stage gas compressor, this machine, running at 200 revolutions a minute, delivers 7000 cubic feet per hour for a maximum pressure of 4300 lb. per square inch. The illustration of this machine shows the intercoolers, the lubricating pump driven from the end of the crankshaft and three separators at the rear. The lubrication in the higher stages when compressing coal gas necessitates a constant renewal of oil, owing to the presence in the gas of benzol, which tends to wash away the oil from the

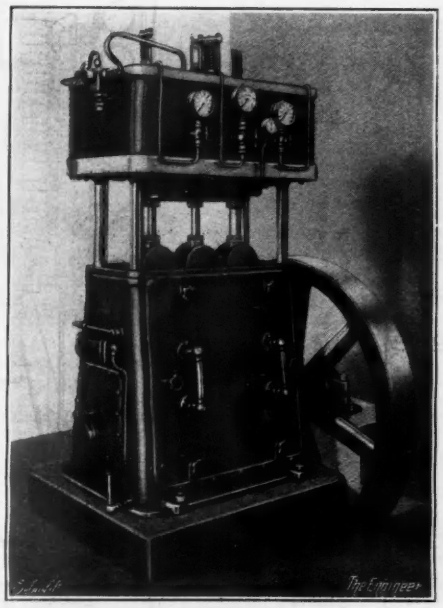


FIG. 100—HIGH-PRESSURE OXYGEN COMPRESSOR—AIR LIQUIDE

cylinder walls. In the same way, separators are an essential equipment of large coal gas compressors, and are provided with special cooling apparatus immersed in water for the elimination of benzol and the heavier hydro-carbons.

Societe l'Air Liquide.

The commercial and technical working of the Georges Claude Patents in France and abroad raises so many new compressor problems that the Société l'Air Liquide, 75, Quai d'Orsay, Paris, was obliged several years ago to undertake the construction of air and gas compressors at works installed for the

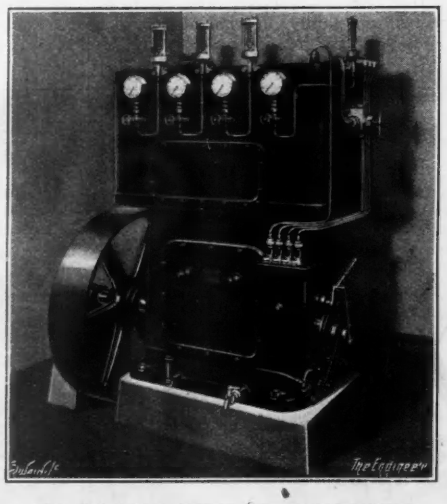


FIG. 101—FOUR-STAGE AIR COMPRESSOR—AIR LIQUIDE

purpose at Champigny-sur-Marne. Practically every kind of compressor plant is required for operations coming within range of the company's activities, from the medium compression of air and other gases to the compression and recirculation of hydrogen and oxygen mixtures up to a pressure of 1000 atmospheres for the synthetic production of ammonia.

An example of a special type of machine is that shown in Fig. 100 for compressing oxygen to 165 and 200 atmospheres. An essential requirement is that the gas shall not come into contact with lubricating oil. As will be seen from the sectional drawing, Fig. 103, the oxygen compressor provides for the insulation of the cylinders from the lubricating system by raising them on four high columns above the crank chamber and base. It is a three-stage machine, and the cylinders of bronze are fixed by high-resistance bronze stud bolts to the cast iron supporting plate carried on the columns. The final compression cylinder has a rustless steel liner. The cylinder heads are removable with the valves, which are of the disc type and are so designed that the same interchangeable parts are employed for the suction and discharge valves of each stage. The bronze pistons have fibre packing. Steel piston-rods pass through stuffing-boxes in the upper supporting plate and in the cover of the three-throw crank base. The stuffing-boxes prevent oil from reaching the cylinders, and in the upper plate they avoid leakage of gas past the pistons to the atmosphere. The cylinders are lubricated by distilled water drawn into the low-pressure cylinder with the gas, the water being separated from the gas at the final discharge. The method of cooling is the same as that adopted in all the compressors with cylinders carried on a plate forming the bottom of a tank containing spiral intercoolers, and the immersion of the cylinders themselves in water is declared to conduce to compressor efficiency. The volume of gas drawn in by the machine illustrated is 30 cubic metres an hour, when running at 150 revolutions a minute, with an absorption of 12 H.P. Oxygen compressors of this type are built for 6 to 600 cubic metres an hour.

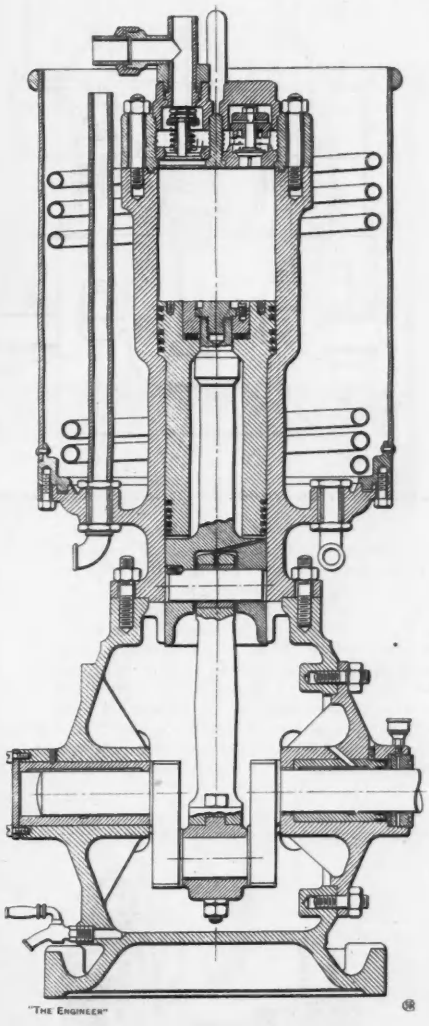


FIG. 102—ACETYLENE COMPRESSOR—AIR LIQUIDE

Eventually the pressure may be raised up to 250 atmospheres with the addition of a fourth stage.

The compression of acetylene requires that the gas shall be discharged without appreciable rise in temperature. For that purpose the same method of cooling is adopted as in the machine just described, and the speed of the compressor is substantially lowered. For a maximum discharge at 22 atmospheres the compressor, Fig. 102, has a vertical single differential cylinder providing two stages. The cylinder is cast with a base to carry a cylindrical tank with a spiral cooler from the discharge valve and filling and overflow pipes. The valves are of the mushroom type arranged for accessibility, and a by-pass is provided to the high and low-pressure bores of the cylinder to be opened when starting up. The big end of the connecting-rod has splash lubrication, and the crosshead is lubricated under pressure and the piston by drop lubrication. Running at 65 revolutions a minute, and absorbing 5 H.P., the compressor delivers 15 cubic metres an hour. Acetylene compressors of this type are built for 5 to 150 cubic metres an hour.

The principle of construction already described is observable in the four-stage vertical machine for compressing 125 cubic metres of air an hour at a maximum of 200 atmospheres, which is shown in Figs. 101 and 104. The third and fourth stages are in tandem with the first and second respectively. The

lower-stage cast iron cylinders with flanges, somewhere about half their length, are inserted into and bolted to a plate welded to the top of the crank chamber. The third-stage cast iron cylinder with flanges is recessed in the lower cylinder and bolted thereto. The fourth-stage cylinder is a steel tube passing through a cast iron flanged piece, which is bolted to the under cylinder. With a shoulder at its lower extremity the tube is passed up through the flanged casting forming the cylinder head and secured by a threaded nut above. The steel tube has a removable cast iron liner, in the same way as the third stage cylinder. The ends of the upper pistons are recessed in the lower pistons and retained by plugs with sufficient clearance to ensure alignment and avoid strains due to expansion. The upper ends of these high-pressure pistons are bevelled in one case and hemi-spherical in the other, corresponding to similar profiles in the cylinder heads with the object of suppressing dead space. In the cooling tank the bottom of which is constituted by the rectangular plate carrying the cylinders, there are four coils for the different stages. The volume of water for cooling is 2 cubic metres an hour. Running at 300 revolutions a minute, the compressor absorbs 47 H.P. at its maximum compression. Air compressors of this type are built from 55 to 1250 cubic metres an hour, the largest sizes being horizontal and provided with five stages of compression.

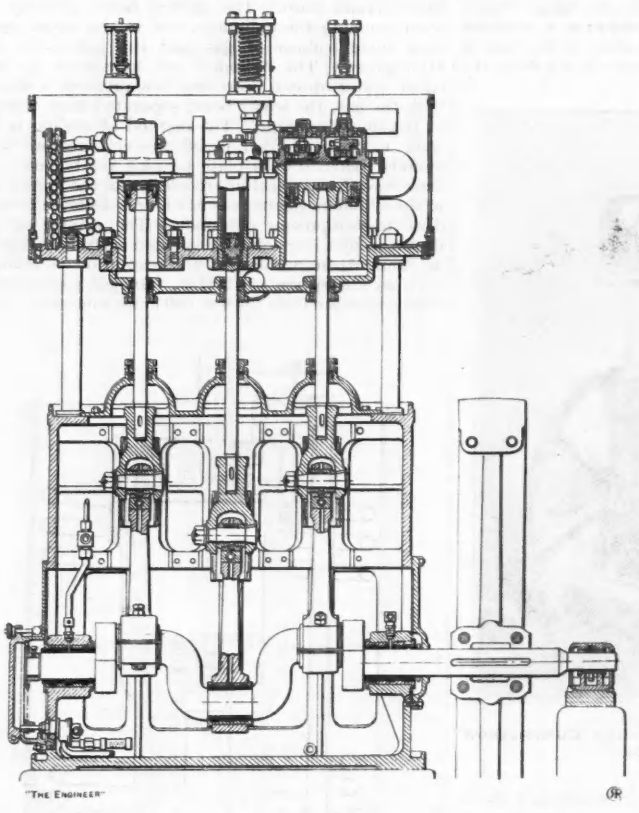


FIG. 103—SECTION THROUGH THREE-STAGE OXYGEN MACHINE—AIR LIQUIDE

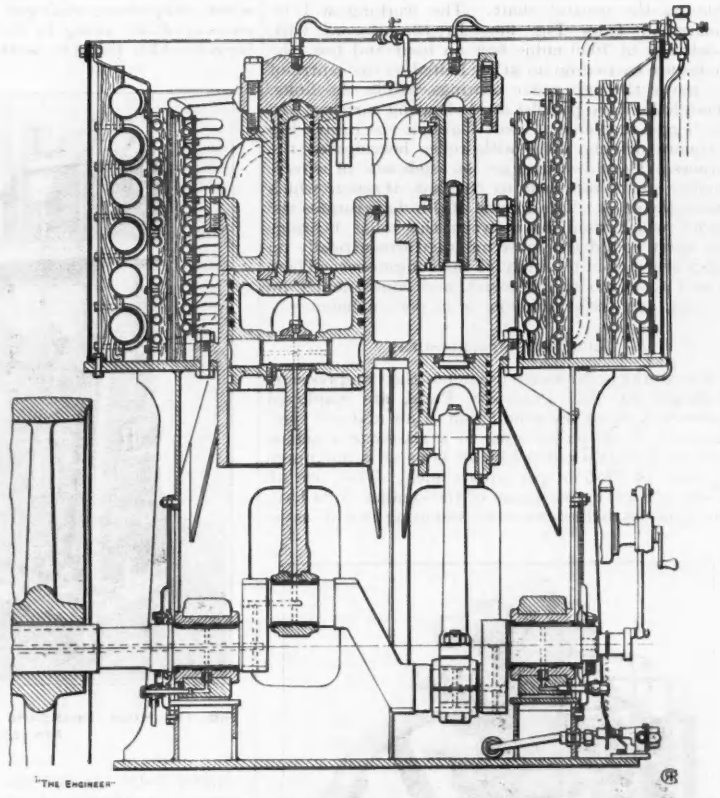


FIG. 104—SECTION THROUGH FOUR-STAGE AIR COMPRESSOR—AIR LIQUIDE

A robust type of three-stage air compressor for delivering 250 cubic metres of free air an hour at a maximum compression of 45 atmospheres is shown in Fig. 105. It has two pistons, one differential and one high pressure. On the upward stroke there is compression in the first and third stages, and suction in the second, and on the downward stroke compression in the second and suction in the other stages. The construction is similar to that of other types described, except that the cylinder is cast with a water jacket.

The synthetic branch of industrial chemistry requires gas compressors working at pressures varying from 15 to 1000 atmospheres for the separation of gases and for synthetic catalysis. For example, coke oven gas is the raw material for many plants installed to work the Claude processes. Hydrogen is separated from this gas by liquefaction of hydro-carbons and other gases mixed with it after compression. Machines for that purpose working between 15 and 30 atmospheres, and similar in construction to that of four-stage air compressors, are built by the Air Liquide company. For the Claude ammonia and methanol synthetic process, the company claims to have built the first industrial machines compressing up to 1000 atmospheres, and named by Monsieur Georges Claude "hypercompressors." These machines, with six or seven stages of compression, have necessitated particular attention to stresses in the metals and to tightness of packings. In the same branch of industrial chemistry pumps are required to raise highly compressed gas mixtures to still higher pressures for circulation, and a pump for this purpose is shown in Fig. 106. It is capable of receiving gas compressed at 600 to 900 atmospheres, raising its pressure by a further 50 to 100 atmospheres and delivering it at the rate of 6000 to 20,000 cubic metres an hour. The machine is horizontal with two opposed cylinders and double-acting pistons. The crank, connecting-rods, and crossheads are compactly housed in the engine bed, with removable cylinders at each end. Reference can only be made to the general features of this machine, the interest of which lies in the methods adopted to ensure gas-tight pistons under the highest pressures, as well as cooling and lubrication under particularly arduous conditions. The pistons are of chrome steel, each bored for a separate water cooling system, which is always under control. Special soft metallic piston packings in one piece are kept tight by the end gas pressure, and are cooled by oil circulation from the general lubricating system. As each piston is double-acting, with a difference in pressure of about 100 atmospheres, it has intermediate cast iron rings against a nitrided cylinder liner which can be easily replaced. All moving parts are lubricated by a gear pump, and the oil returns to the circuit through filters in a cooling tank. The delivery of this high-pressure circulating pump can be varied to a large extent by keeping the suction valves more or less

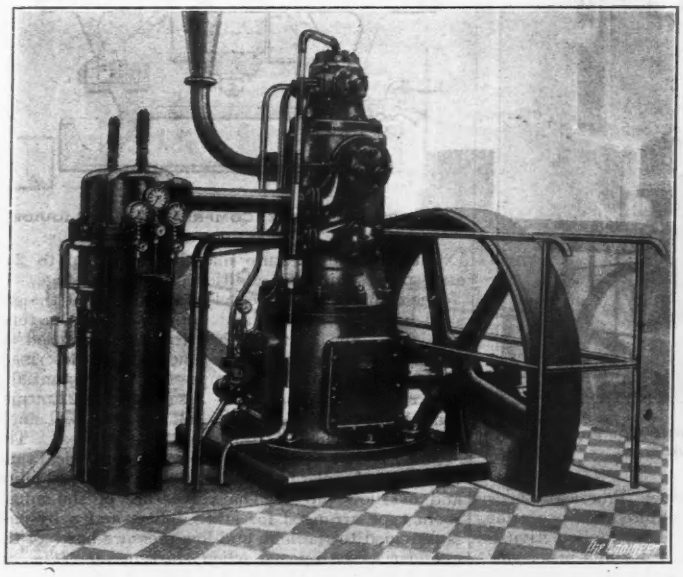


FIG. 105—THREE-STAGE AIR COMPRESSOR—AIR LIQUIDE

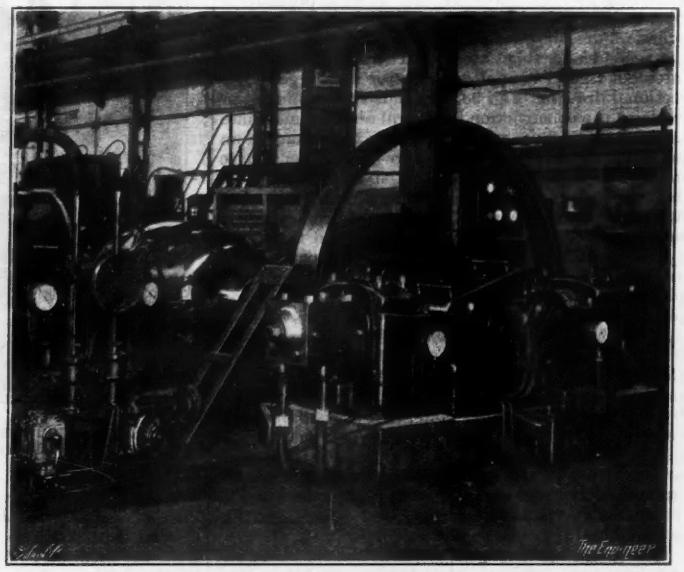


FIG. 106—RE-CIRCULATING GAS PUMP—AIR LIQUIDE

open, so that there is no necessity to run the machine at varying speeds with loss of efficiency.

SWITZERLAND.

In Switzerland makers of air compressors and blowers have during the past few years experienced an increase in business, which has led to progress in design and the development of new types of machines. Large machines for the high-pressure compressing of

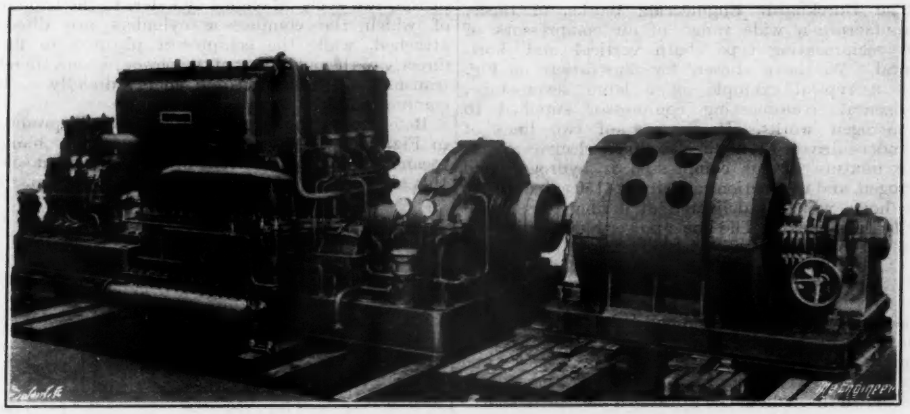


FIG. 107—12,000-CUBIC FOOT CENTRIFUGAL COMPRESSOR—BROWN-BOVERI

air and gas are usually of horizontal design, and steam is freely employed as the motive power. For smaller machines electrical drive is frequently preferred, and gas turbines are sometimes used. Welding is coming to play an important part in compressor manufacture, and the casings of centrifugal compressors and blowers, especially when the machines are called upon to deal with corrosive gases, are frequently built up welded structures. It is also employed for the construction of intercoolers.

BROWN-BOVERI AND CO.

The practice of Brown-Boveri and Co., of Baden, accords closely in our own country with that of Richardsons, Westgarth-Brown, Boveri, Ltd., of West Hartlepool and London. The standard design of the Brown-Boveri centrifugal compressor, using three pairs of intercoolers, has recently been modified for sizes up to 25,000 cubic feet per minute in order to improve efficiency and to give more satisfactory operation within the surge limit. This new design of compressor is illustrated in Fig. 107, The compressor has two banks of intercoolers, which are bolted to the top and bottom halves of the casing. Cooling is provided after each stage, with the exception of the first and last. The special arrangement of the intercoolers and the use of ribbed intercooler tubes permits the employment of a much larger cooling surface than would otherwise be possible. At the end of the unit nearest the gearing will be seen the three regulating valves of the recuperation anti-surge turbine. This device consists of a small impulse wheel mounted on the compressor shaft. For demands below the surge point such additional air, over and above that required to meet the demand, as is necessary for keeping the machine from surging, is by-passed from the discharge through the turbine to atmosphere. By this arrangement the energy expended in compressing the surplus air is recovered, and smooth control over the whole of the operating range is effected. The unit we illustrate in Fig. 107 has a designed capacity of 12,000 cubic feet of free air per minute delivered at a gauge pressure of 106 lb. per square inch. At one end the turbo-compressor is connected to an electric motor through gearing, while at the other it is coupled to a gas turbine supplied with gas at 92 lb. pressure and a temperature of 930 deg. Fah. The gas is expanded to the atmosphere and develops about 75 per cent. of the required input to the compressor.

Another interesting Brown-Boveri machine which we do not illustrate is a small compressor of the centrifugal pattern which has been supplied to the South African Iron and Steel Corporation, of Pretoria, for dealing with the small quantity of about 3000 cubic feet per minute, at a compression ratio of eleven. It is turbine driven and has a maximum output speed of 17,400 r.p.m.

A feature of the practice of the last few years has been the revival of interest in the axial flow compressor of the reversed turbine type. It may be recalled that the first commercial axial flow blower or compressor was built in 1901 by Sir Charles Parsons for supplying blast to a lead-smelting furnace on the Tyne. Few machines of this type were, however, constructed, and the centrifugal type was preferred. In recent years, however, multi-stage axial blower design, especially with the gas turbine drive, has been revived in connection with the charging units for Velox boilers, and successful commercial designs for comparatively large machines have been introduced. It has been found that for volumes in excess of 30,000 to 40,000 cubic feet per minute and for delivery pressures not exceeding 45 lb. per square inch, the axial flow compressor offers certain advantages compared with the centrifugal type, mainly on account of its higher efficiency and its more simple form of construction. We illustrate in Fig. 108 one of several sets supplied for supercharging in an oil refining process. The sets run on residual gas and our engraving clearly shows the reaction blades of the multi-stage gas turbine, and the simple form of the rotor and blades of the compressor. Considerable care has been expended on research work connected with blade design, which incorporates many features deduced from aero-dynamical research.

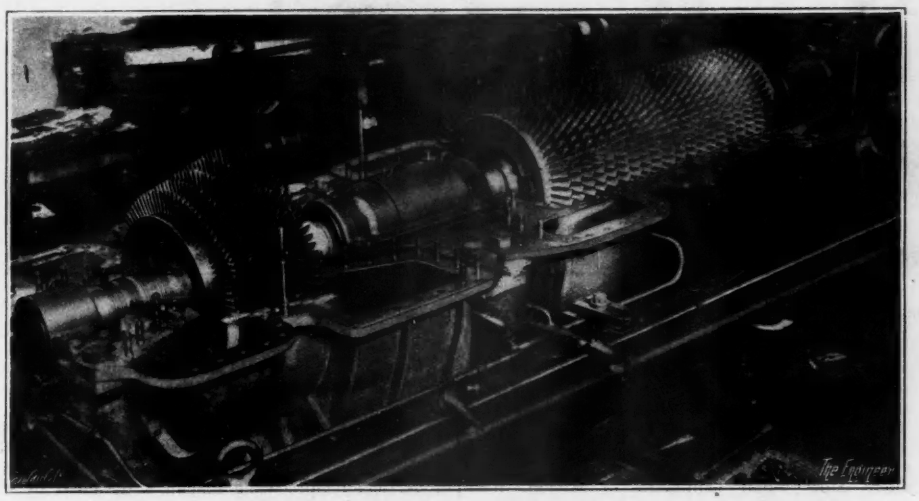


FIG. 108—TURBINE-DRIVEN "REVERSED TURBINE" COMPRESSOR—BROWN-BOVERI

SULZER BROTHERS.

Among the air and gas machines made by Sulzer Brothers, of Winterthur, and Bedford-square, London, are gas compressors such as are used in the chemical industry, particularly for synthetic ammonia and hydrogenation plants. They are built up to the largest capacities and pressures ranging between 300 lb. and 15,000 lb. per square inch, and special designs are available for handling impure gas. A very common arrangement is a multi-stage compressor dealing with raw gas in the lower and purified gas in the upper stages, the impurities being removed in special scrubbers working at suitable intermediate pressures. At the present time, a large compressor of this type is being erected in the works at Winterthur. It comprises six compression stages linked up with two steam engine cylinders with an output of 1900 I.H.P. Three compressors of the same design and similar capacity have been built before, and one of them is illustrated in Fig. 109.

For pressures above 5000 lb. and up to 15,000 lb. per square inch, the Sulzer hyper-compressors differ materially from usual designs owing to their special features, such as the vertical arrangement of the two hyper-stages and the hydraulic drive of the plungers. The arrangement is shown in Fig. 110. The primary oil cylinder is fitted between the frame and the

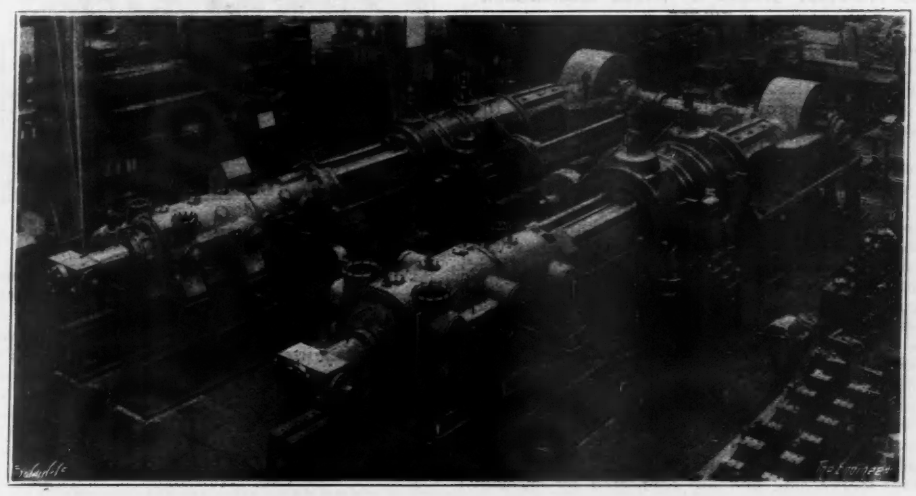


FIG. 109—SIX-STAGE HIGH-PRESSURE GAS COMPRESSOR—SULZER

cylinder for the fourth stage on the high-pressure side of the compressor, whilst the secondary oil cylinders stand at both ends of the primary oil cylinder, with the gas cylinders of the sixth and seventh stages arranged vertically on top. The arrangement is kept as compact as possible, so as to obtain a short column of oil. An oil pipe of ample size runs from both sides of the primary oil piston to below each of the secondary pistons, in such a way that the motion of the primary system is transmitted directly to the secondary pistons by means of hydraulic columns. Unavoidable loss of oil through leakage, blowing off of valves, or the limitation of the stroke, would shorten the column and thereby tend to make transmission of movement inexact. Such loss is therefore compensated automatically by a supplementary feeder pump after each stroke. As indicated in the drawing, provision is also made for limiting the stroke of the plungers for the sixth and seventh stages, which is equivalent to regulation by altering the clearance, thereby providing flexibility of output. Such compressors are built for large outputs only.

For the field of air supply systems, Sulzer's construct a so-called oilless compressor, which is of the enclosed vertical pattern and is furnished with a piston of rustless steel, with an outer lining of special white metal containing labyrinth grooves, running in a liner of special anti-corrosive cast iron. Owing to absence of friction inside the cylinder, the compressor requires no lubrication whatever of any part coming in contact with the air to be compressed. Consequently, a perfectly clean compressed air supply can be guaranteed. A machine of this description has been installed in a Swiss brewery, and for another brewery a similar com-

pressor is now being built for the handling of CO_2 gas. Wherever compressed air comes in contact with delicate goods, foodstuffs, beverages, &c., a compressor which can be guaranteed not to contaminate the air in any way is essential. It is well known that with ordinary compressors it is practically impossible to guarantee a pure air supply, as even the best separators and filters will not extract the last trace of oil taint out of an air supply that during compression has been in contact with lubricated parts. This new compressor, therefore, marks a development of undoubted interest.

ESCHER WYSS ENGINEERING WORKS.

Quite recently the Escher Wyss Engineering Works, of Zurich, and Terminal House, Grosvenor-gardens, London, has, by means of research methods utilising

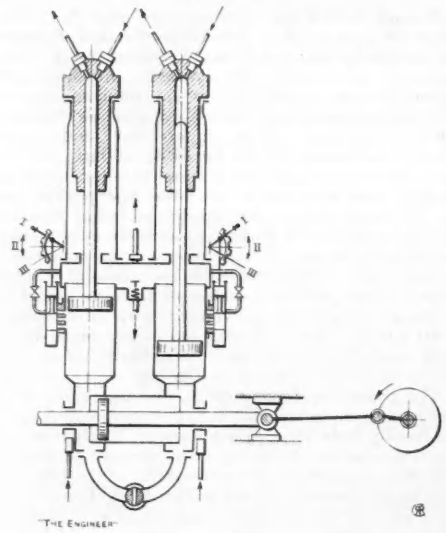


FIG. 110—FINAL STAGES OF HYPER COMPRESSOR—SULZER

laboratory models, studied the shapes of turbine blades, impeller, and diffuser passages, and has as the result of these experiments been able to effect considerable improvements in the design of the steam and water turbines and compressors built by the firm. Fig. 113 illustrates in diagrammatic form a section through a modern centrifugal compressor. The special feature to be noted is the design of the diffusers and return channels, which are so disposed that a partial conversion of kinetic energy into pressure is effected in the return channel, as well as in the diffuser. The manner in which the air is guided is shown in the drawing, which depicts a sectional arrangement of a modern four-stage blower. Important improvements have also been made in the design and arrangement of intercoolers. The new pattern of intercooler is shown in Fig. 112, which is a bird's-eye view of one of the latest Escher Wyss turbo-compressors with a designed output of about 2000 cubic feet per minute of free air delivered at a pressure of 110 lb. per square inch. The intercoolers are grouped at the back of the compressor casing and are connected by specially shaped inlet pipes, the design of the air passages and the intercooler tubes being such that the kinetic energy in the air is converted to a large extent into pressure. The cooler tubes are of drop-shaped, streamlined section, and are furnished with ribs or gills. The intercoolers of this new type are claimed to give high heat transmission, while the pressure losses within the cooler are reduced.

The firm has recently developed a series of single and multi-stage axial-flow blowers, which are recommended for large volumes of air to be delivered at moderate final pressures. In some designs arrangements are made to vary the pitch of the blades as with a Kaplan turbine. By this means widely differing working conditions can be met, and high efficiencies maintained. Axial-flow compressors with fixed blades have been developed in machines of eight to twelve stages, and have been successfully employed for blast-furnaces with pressures of 12 lb. to 18 lb. per square inch, the efficiencies obtained being considerably higher and the space required less than with turbo-compressors of the centrifugal type having the same designed duty.

THE BURCKHARDT ENGINEERING WORKS.

The Burckhardt Engineering Works, of Basle, manufacture a wide range of air compressors of the reciprocating type, both vertical and horizontal. We have chosen for illustration in Fig. 111 a typical example of a large seven-stage, horizontal, reciprocating compressor supplied to a nitrogen works. It consists of two lines of cylinders driven by a direct-coupled electric motor. The mixture of gas compressed is hydrogen and nitrogen, and the suction capacity is 4150 cubic metres per hour, which is delivered at a final pressure of 1000 atmospheres. The horse-power required is 1636 and the compressor runs at 125 r.p.m.

GERMANY.

German engineers were amongst the pioneers on the Continent in the design and use of horizontal blowing engines for blast-furnaces, and the steam and gas engine driven units built by Demag and M.A.N. are known throughout the world. In the field of centri-

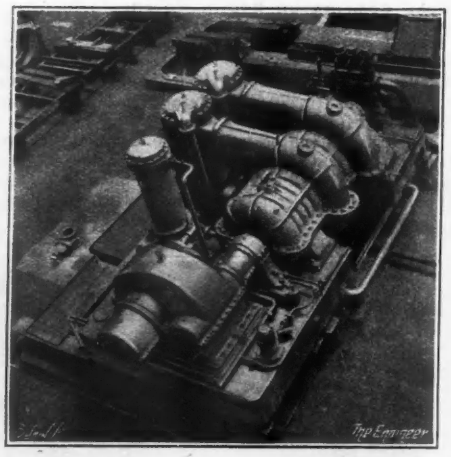


FIG. 112—TURBO-COMPRESSOR—ESCHER WYSS

fugal and turbo-compressors, and also rotary compressors, much development work has been recently done, and to-day Germany holds a high position in the design and construction of large air and gas machines for the iron and steel and chemical industries. The small space at our disposal in the present Supplement will not allow us to deal at length with many of the more familiar designs which have been, and will be from time to time the subject of longer articles. We have chosen, therefore, for description some new compressors of outstanding interest which, we think, mark new departures in air compressor practice.

JUNKERS MOTORENBAU G.M.B.H.

An air and gas compressor of unusual and interesting design is the free-piston, crankless compressor invented by the late Professor Dr. Hugo Junkers, which, after prolonged research and development, is now in commercial production and is manufactured in three different types, covering a wide range of pressures and outputs for industrial, marine, and naval services. The compressor is made by the Junkers Motorenbau G.m.b.H., of Allach, near Munich, represented in this country by Trost Brothers, Ltd., of 110, Victoria-street, Westminster.

A typical example of a commercial type of two-stage unit has a designed engine output of 95 B.H.P. at 480 cycles per minute, corresponding to a rated output of 425 cubic feet of free air per minute delivered at a pressure of 100 lb. per square inch. As our illustration—Fig. 114—clearly indicates, the Junkers free-piston, crankless compressor comprises an engine and compressor in a single unit, the pistons having a purely reciprocating motion, without, however, using any crankshaft or fly-wheel. The prime mover portion of the unit consists of a centrally arranged, opposed piston, two-cycle oil engine cylinder, to the two ends of which the compressor cylinders are directly attached, while the compressor pistons are fixed directly to the outer ends of the power pistons, thereby transmitting the combustion energy directly to the compressed air.

Reference to the diagrammatic drawing reproduced in Fig. 114 will show that there are no mechanical means for limiting the stroke of the pistons, but solely the air cushion between the two working pistons

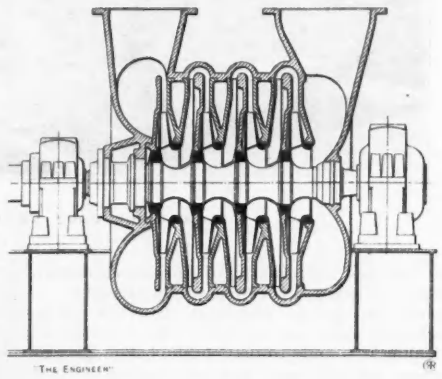


FIG. 113—TURBO-COMPRESSOR—ESCHER WYSS

on the instroke and the air cushions in the compressor cylinders on the outstroke, which serve also to effect the return stroke of the pistons after each firing stroke. The motions of the two pistons are kept in unison by a simple rack and pinion arrangement shown in Fig. 116, the pinion of which also serves for driving the fuel pump and the lubricating and circulating pumps.

Fuel injection is by a Junkers type jerk pump with an open nozzle, the amount of fuel delivered being regulated by rotating the fuel pump plunger thus altering the effective delivery stroke of the pump. In the compressor, all suction and delivery valves are of the fully automatic, spring-loaded, disc pattern. A pressure-retaining valve behind the high-pressure cylinder automatically regulates the pressure in each stage. As will be seen from Fig. 117, the whole unit is enclosed in a cylindrical water-jacketed casing. Intercoolers are provided between the stages of compression with a final cooler after the last stage, with the necessary pressure gauges.

Starting is effected quite simply by admitting compressed air into the compressor cylinders.

Engraving Fig. 117 shows a high-pressure unit having an engine output of 50 B.H.P. at 860 cycles per minute with a rated output of 70 cubic feet of free air per minute delivered at pressures from 3000 lb. to 4400 lb. per square inch. The weight of these compressors is claimed to be very much less than any other type of compressor of the same capacity, and service results would seem to point to reliability, and long life, with low maintenance costs.

BORSIG-RHEINMETALL.

Among air compressors recently placed on the market in Germany we may mention the new series of vertical reciprocating machines designed by the Borsig Works of the Rheinmetall-Borsig Company at Berlin Tegel, a firm which has had more than forty

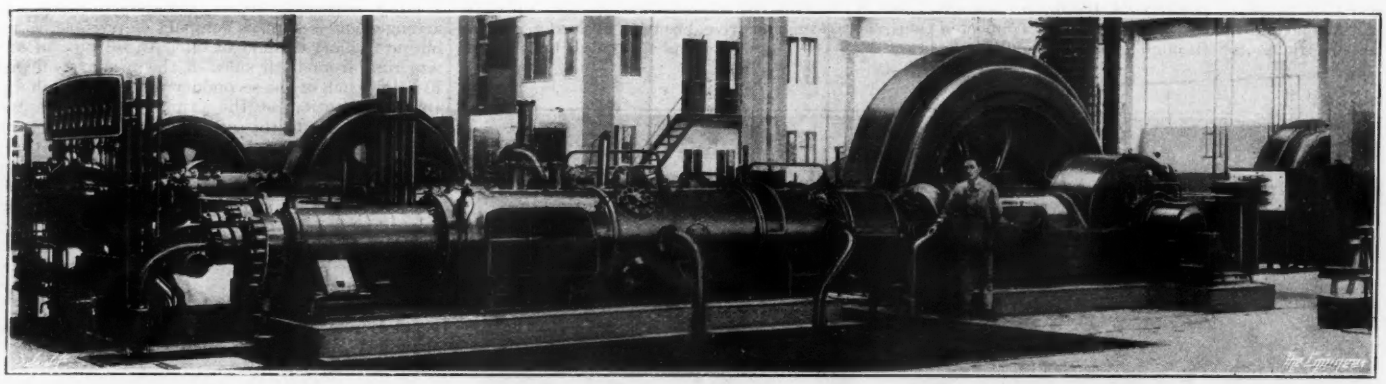


FIG. 111—FIVE-STAGE TWO LINE MIXED GAS HORIZONTAL COMPRESSOR—BURCKHARDT

years of experience in compressor design. We illustrate in Fig. 115 one of this new series, which is built in a range of outputs from 15 to 125 cubic metres per minute with a final delivery pressure up to 10 atmospheres. The running speed, which decreases with increasing size, varies between 300 r.p.m. for the smaller and 725 r.p.m. for the larger units. The compressor has been specially designed for driving either by electric motor or by an oil engine. A feature is the totally enclosed casing and the generally

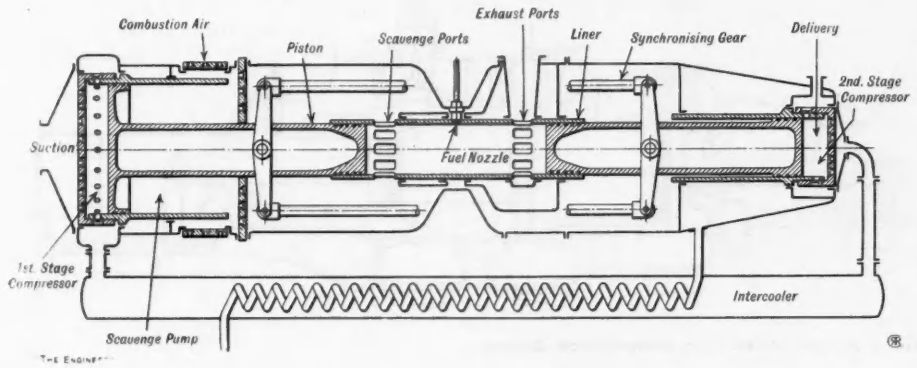


FIG. 114—FREE PISTON CRANKLESS COMPRESSOR—JUNKERS

clean arrangement of the various parts and the absence of unnecessary pipe connections. The working parts are accessible through inspection covers. The high-pressure and low-pressure cylinders are cast in a single block and are bolted directly to the columns. The valves are of the spring-loaded disc pattern and the suction and delivery valves are mounted on one spindle and are housed vertically at

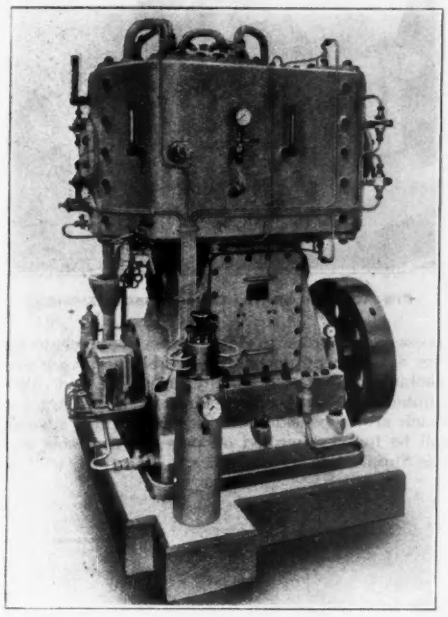


FIG. 115.—VERTICAL TWIN CYLINDER COMPRESSOR—BORSIG

the sides of the cylinders. The stuffing-boxes are furnished with spring packings, which can be adjusted while the compressor is running. For lubricating the working parts a mechanical lubricator is employed, and it has been possible to reduce the oil required to about 0·2 gramme per I.H.P. hour, a figure which compares with nearly 1·2 grammes per I.H.P. hour for trunk piston and rotary designs. It is claimed that

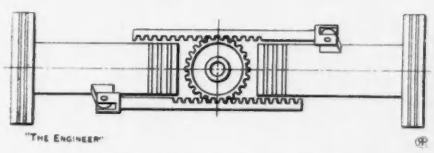


FIG. 116—CONTROL OF PISTONS—JUNKERS

the air and gas delivered is practically free of oil. Special interest attaches to the design and arrangement of the intercooler elements, which we illustrate in Figs. 118 and 120. The intercoolers are arranged in parallel and are housed one on either side of the high-pressure cylinder. They are easily removed for cleaning and by the use of ribbed intercooler tubes a greater cooling capacity is obtained than would be possible with ordinary tube nests. The space taken up is small and compares favourably with other types of compressor for similar duties. Practical running experience indicates, so the makers state, that after a period of 6500 working hours there is no appreciable wear either in the running parts or the valves. The compressor is furnished with the Borsig patented suction valve control, which is automatic in its operation and can deal, it is claimed, with load variations from 10 to 100 per cent. These new compressors have, we are informed, achieved considerable success both in Germany and abroad, and the smaller sizes up to 50 cubic metres per minute are made in series ready for immediate despatch and erection.

SIEMENS SCHUCKERT COMPANY.

An interesting chlorine compressor of novel design which has been recently placed on the market by the Siemens Schuckert Company, of Siemensstadt, Berlin, and London, is illustrated in Fig. 122. It was to be seen at the recent Leipzig Fair. The compressor operates on the rotary principle, employing a ring of liquid. Up to the present it has only been possible to produce with this type of compressor pressures of chlorine gas up to about 0·6 atmospheric gauge pressure. By the use of a novel method for guiding the liquid ring, however, Siemens Schuckert have been able to increase the delivery pressure of the chlorine gas to about 3 atmospheres without causing too severe a stress on the shaft and the impeller. The operating liquid used is concentrated sulphuric acid, which seals the impeller chambers and also serves to remove the heat developed during the compression of the gas. The casing is made of a special corrosion resisting cast iron and the packings employed are of the asbestos type. The compressor has been specially designed to meet the full requirements of dangerous chemical plants. In its construction special care has been bestowed on the design and cooling of the stuffing-boxes and the protection of the shaft and the bearings, while convenient withdrawal of the separate parts for dismantling has been borne in mind. The compressor we have described has a designed suction capacity of about 3 cubic metres, or, say, 105 cubic feet of gas per minute.

DEMAG COMPANY.

The Demag Company of Duisburg not only specialises in the production of very large reciprocating air and gas compressors, but also turbo and rotary compressors, which are dealt with in London by Demag and the Rotary Air Compressor Company, Ltd., at 119, Victoria-street, Westminster. As examples of the pressure compressors produced by the firm, we may take three which were built for a nitrogen works. Each compressor has a suction capacity of 3533 cubic feet per minute of free mixed gas. The suction pressure is 142 lb. per square inch above atmospheric and the final pressure 14,223 lb. per square inch abs. The gas is compressed in four pressure stages up to a normal delivery pressure of 12,100 lb., and a maximum delivery pressure of 12,800 lb. per square inch above atmospheric. The compressor is coupled direct to a firedamp-proof squirrel-cage motor, with eddy current rotor, which can be connected directly to the 5000-volt main without any starting apparatus. The speed of the driving motor is 122 r.p.m., and the power required at the shaft for driving the compressor with an electric motor is 1650 H.P.

Another compressor, which we illustrate in Fig. 119, is designed for compressing coke-oven gas at a nitrogen works. It is a three-stage machine driven by a three-phase motor, and runs at 122 r.p.m. The designed suction volume is 3116 cubic feet per minute, and the final pressure 185 lb. per square inch above atmosphere. The centrifugal compressors made by Demag are in design and construction generally similar to those of the British licensees of the firm, Daniel Adamson and Co., Ltd., and some particulars of these units will be found in the British Section of this Supplement.

Other recent Demag developments include the use of compressors for gas-filling stations, which are now freely used in Germany for supplying home-produced liquid and gaseous fuels for motor transport vehicles. The gases mainly employed are propane, butane, coke-oven, and town's gas and wood gas, and for the service vertical and horizontal reciprocating compressors are employed, with final pressures up to 5000 lb. per square inch. A typical gas-filling compressor installation was recently shown at the Leipzig Fair, and also at the Düsseldorf Exhibition. A further use for compressors is for the Heskamp

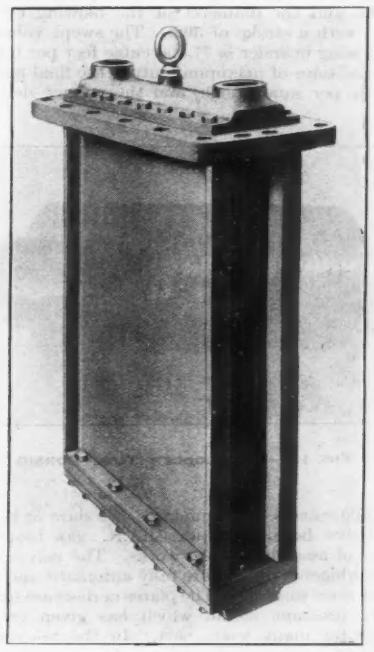


FIG. 118—INTERCOOLER—BORSIG

process of blowing out throat dust in blast-furnaces, to which we hope to refer more fully in a later article.

M.A.N.

The works of the Maschinenfabrik Augsburg-Nürnberg A.G., which is represented in this country by Spannagel, Ltd., of 13–15, Old Queen-street, Westminster, have for the past thirty-five years specialised in the construction of large gas engines and gas blowing engines. It is of interest in this connection to place on record that the firm's latest installation in this country which will shortly be put to work at the Appleby-Frodingham Steel Company's works of the United Steel Companies

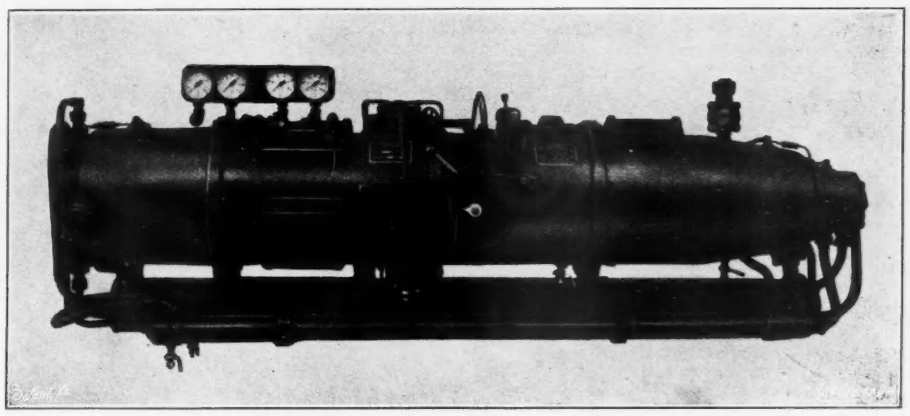


FIG. 117—FREE PISTON CRANKLESS COMPRESSOR—JUNKERS

group, will embody the latest improvements in this particular type of plant.

The installation comprises three gas engine-driven blowing engines taking gas of 100 B.Th.U. calorific value from coke-oven plant. Each of the three sets will have a blowing capacity of 66,000 cubic feet per minute, with a final delivery pressure of 16 lb. per square inch. The engines, when running at a normal speed of about 86 r.p.m., will each develop approximately 3400 I.H.P. The diameter of the gas cylinder is 59in. and the diameter of the blowing cylinder 130in., with a stroke of 59in. The swept volume of the blowing cylinder is 77,000 cubic feet per minute. For conditions of maximum output the final pressure is 24 lb. per square inch, and the volume delivered is 55,000 cubic feet per minute. We show in Fig. 121 the valve housing of an M.A.N. gas blower in course of assembly in the works. The valves are of the Hörbiger type, and are fully automatic and noiseless in their working. The plates or discs are made of highly resistant metal, which has given excellent results for many years past. In the re-expansion spaces the valves are operated by compressed air. The blower piston is a simple disc and the blower piston and piston-rod are supported by white metal lined slippers of generous dimensions, which run in oil. Particular attention is paid to the design and construction of the stuffing-boxes with a view to giving easy accessibility.

According to investigations made by Mr. M. Steffes, of Luxemburg, from gas blowing engines in long service, the amount of heat consumed by an up-to-date steam turbine-driven blower may in some cases rise to 1·7 times that used by a gas engine-driven piston blower with lower working costs. Operating conditions may vary widely, but there are a large number of works with an excess of gas, where gas engine blowers may be profitably employed.

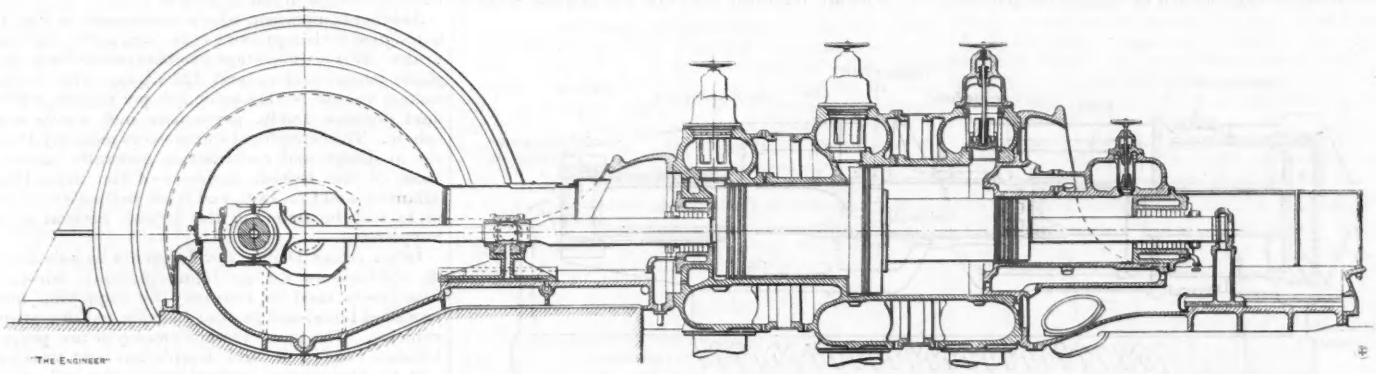


FIG. 119—COKE OVEN GAS COMPRESSOR—DEMAG

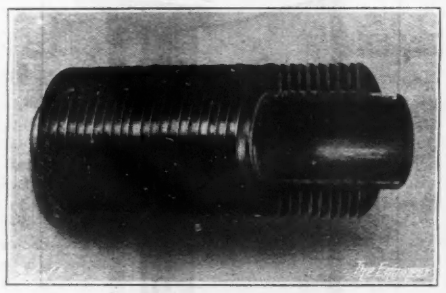


FIG. 120—INTERCOOLER TUBE—BORSIG

FIG. 121—BLOWER VALVE HOUSING—M.A.N.

CONCLUSION.

In concluding this survey of compressor and blower practice from many parts of the world, we wish to acknowledge our indebtedness to the many manufacturers and others who have supplied us liberally with the technical information, drawings, and photographs which we asked for, despite the fact that they were, and still are, labouring under very considerable stress of work. During preparation this Supplement was increased in size beyond that originally contemplated. But, even so, it has only been with difficulty that the material offered to us has been accommodated in its thirty-six pages. It was, however, found necessary, in order to do it justice, to exclude from this Supplement not only portable and very small machines, as was originally intended, but also a number of other small machines of rather larger size which are of considerable interest. These machines will be found described on pages of the issue which this Supplement accompanies.

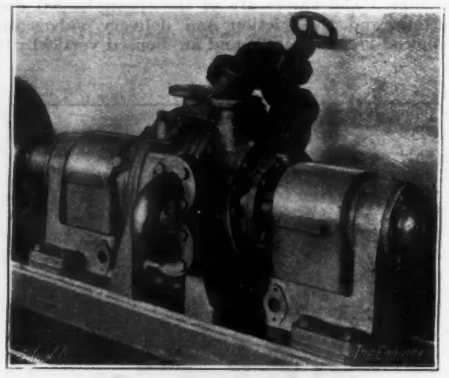


FIG. 122—CHLORINE COMPRESSOR—SIEMENS

Printed on thin paper for overseas circulation.

The Engineer

LONDON, FRIDAY JUNE 3, 1938.

PUBLIC NOTICES.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Friday, 1st July, 1938, for the SUPPLY, DELIVERY, and COMPLETE ERECTION of TURBINES, ALTERNATORS, SWITCHGEAR, REDUCING VALVES, DESUPERHEATERS, TRANSFORMERS, CABLES, CRANES, BATTERIES, FREQUENCY CONTROL, CONTROL SIGNALS, &c., at the Royal Ordnance Factory, Bishopton, Scotland.

Drawings, specification, a copy of the conditions and form of contract and forms for Tender, may be obtained from Room 65 D, Third Floor, H.M. Office of Works, London, S.W.1, on payment of One Pound. (Cheques payable to the COMMISSIONERS, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions.

The Commissioners are not prepared to consider Tenders for separate items. 4720

Air Ministry.
DIRECTORATE OF TECHNICAL DEVELOPMENT.
APPLICATIONS are INVITED for an APPOINTMENT as ASSISTANT, GRADE I, at the Royal Aircraft Establishment, South Farnborough, Hants. Candidates should have had training to the standard of a University Degree in Physics, Mathematics, or Engineering, and have had considerable experience in the Design and Construction of Instruments and Small Mechanisms, and be able to Analyse Experimental Test Results. A knowledge of the Functioning and Design of Gyroscopic Apparatus and Optical Instruments would be an advantage, and some Drawing Office and Workshop or Laboratory Experience is desirable. Candidates should be physically fit for flying and willing to fly as observers.

Salary Scale: £400 by annual increments of £18 to £515 a year (Women, £315 by £12 to £400 a year).

The appointment will be non-pensionable, but the entrant will be eligible for consideration for appointment to a pensionable post in the event of a vacancy arising on the permanent establishment.

Application should be made on a form to be obtained (quoting Ref. No. 55 C.) from the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it should be returned not later than 18th June, 1938. 4723

Air Ministry.
APPLICATIONS are INVITED for CIVILIAN POSTS of DRAUGHTSMEN, GRADE II, at various Royal Air Force Stations. Candidates should have had a good technical training, Engineering Workshop and Drawing Office experience.

Salary: Up to 82s. a week, depending on qualifications and experience. Promotion to Draughtsman, Grade I (£220-10-£260-12-£330 per annum), is governed by merit as and when vacancies arise.

Grade II appointments are non-pensionable. Draughtsmen, Grade I, and above are eligible for consideration for appointment to pensionable posts in the event of vacancies arising on the permanent establishment.

Application should be made on a form to be obtained (quoting reference No. B.505) from the UNDER SECRETARY OF STATE, Air Ministry, S.2.D. (S.205), Adastral House, Kingsway, W.C.2, to whom it should be returned. 4447

Air Ministry.
DIRECTORATE OF TECHNICAL DEVELOPMENT.
APPLICATIONS are INVITED for an APPOINTMENT as DRAUGHTSMAN, GRADE I, at the Royal Aircraft Establishment, South Farnborough, Hants. Applicants must be qualified and experienced in Structural Design and General Engineering Work, and must be capable of all stress calculations.

SALARY SCALE.—£220 a year, rising by annual increments of £10 to £260 (efficiency bar), and thence by £12 to £330 a year. Commencing salary up to £260 a year, according to qualifications and experience.

The appointment will be non-pensionable, but the entrant will be eligible for consideration for appointment to a pensionable post in the event of a vacancy arising on the permanent establishment.

Application should be made on a form to be obtained (quoting Ref. No. 70C) from the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it should be returned not later than 17th June, 1938. 4740

Air Ministry.
DIRECTORATE OF AERONAUTICAL PRODUCTION.
APPLICATIONS are INVITED for a TEMPORARY APPOINTMENT as PRODUCTION OFFICER. Applicants should have had a good general and technical education and practical Works Experience in Industrial Chemistry and Metallurgy. Preference will be given to candidates with Production Experience.

Commencing salary £400-£500 per annum, according to qualifications and experience.

Applications, giving full particulars as to qualifications, previous experience, age, &c., should reach the PERMANENT UNDER-SECRETARY OF STATE (S.I.f.), Air Ministry, Kingsway, W.C.2, not later than 14th June, 1938. 4722

Crown Agents for the COLONIES.
COLONIAL GOVERNMENT APPOINTMENTS.
APPLICATIONS from qualified candidates are INVITED for the following POSTS:—

M/5912.—ENGINEER REQUIRED for the Nigerian Government Collieries for two tours, each of 12-24 months, with possible permanency. Salary £475 a year, rising to £840 a year. Free passages and quarters and liberal leave on full salary. Candidates, aged 26-36, should be Corporate Members of the Institution of Mining Engineers or University Graduates in Engineering. They must have had a practical training in a British colliery and be experienced in the supervision of all colliery machinery and plant and in the construction and maintenance of buildings. They must also be conversant with A.C. electrical plant as applied to general colliery practice.

M/5886.—ENGINEER REQUIRED by the Government of Nigeria for the Public Works Department (Temporary Staff) for two tours of 12 to 24 months each, with possible extension and eligibility for transfer to the permanent and pensionable establishment. Fixed salary ranging from £500 to £720 a year, according to qualifications and experience; a higher salary may be reached if transferred to the permanent establishment. Free passages and quarters and liberal leave on full salary. Candidates, aged 23-40, must hold a University Degree in Civil Engineering or have passed Sections A and B of the A.M.I.C.E. examination, or the Associateship in Civil Engineering of the City and Guilds Institute; have had practical experience of road and bridge or similar construction, surveying and levelling; and be able to set out and take charge of works.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications, and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting the reference number against the appointment for which application is made. 4752

The Engineer

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PUBLIC NOTICES.

Air Ministry.
APPLICATIONS are INVITED for the undermentioned APPOINTMENTS in the Directorate of Armament Development, Air Ministry Headquarters:—
ONE TECHNICAL OFFICER (Reference B.46).

Salary scale £273 by 18-£455 by 25-£580 a year (men, £275 by 12-£347 by 18-£464 a year (women). There is an efficiency bar at £455 a year (men) and £347 a year (women).

Promotion to the higher grade of Senior Technical Officer (£680 by 25-£800 (men) and £580 by 25-£680 (women)) and above is governed by merit as and when vacancies arise.

ONE ASSISTANT I (reference B.48).

Salary scale £400 by 18-£515 a year (men), £323 by 12-£349 by 18-£415 a year (women).

Candidates should have had training to the standard of a University Degree in Engineering and possess a good knowledge of metals and stresses. Ability to read blue prints thoroughly is necessary, while some experience in administrative work is desirable.

The appointments will be non-pensionable, but entrants will be eligible for consideration for pensionable posts in the event of vacancies arising on the permanent establishment.

Application should be made on a form to be obtained, quoting the appropriate reference, from the UNDER-SECRETARY OF STATE, Air Ministry (S.2.D), Adastral House, Kingsway, W.C.2, to whom it should be returned not later than the 23rd June, 1938. 4760

Mechanical Draughtsmen REQUIRED, preferably with experience on any of the following types of work:—
War Stores,
Commercial Vehicles (Chassis or Trailers),
Jigs and Tools.

Applicants should have had not less than three years' workshop experience. Age 21 years to 30 years. Preference given to ex-Service men, other things being equal. Pay up to 82s. per week according to ability and experience. Posts are non-pensionable, but, subject to suitable qualifications, entrants are eligible for consideration for promotion and for appointment to the pensionable establishment should vacancies arise.

Application forms obtainable by postcard from CHIEF SUPERINTENDENT of ORDNANCE FACTORIES (Advt. No. 218), Royal Arsenal, Woolwich, S.E.18. 4593

PUBLIC NOTICES.

Board of Trade.
STANDARDS DEPARTMENT.
A VACANCY for an ESTABLISHED EXAMINER in the Standards Department of the Board of Trade has arisen. The post is open to men and women and the first two years' service will be probationary. The duties are mainly in connection with the Control of Standards, and with the Examination of Weighing and Measuring Apparatus of Novel Types with a view to their Approval for use in Trade.

Every candidate must be under the age of 45 years on the 18th June, 1938; must be a natural-born British subject, the child of a person who is, or was at the time of death, a British subject, and should possess a University Degree (or its equivalent) with qualifications in Science or Engineering, and have had practical Workshop Experience.

Preference will be given to ex-Service men.

The scale of salary is, for men and women, £246 9s. (first year), £258 9s. (second year), £270 9s. (third year). At the end of the third year, subject to satisfactory service, a man will be placed on a scale of £337 7s. by annual increments of £18 to £515 18s. a year, and a woman on a scale of £320 by annual increments of £12 to £356 and of £18 to £412 15s. a year.

Applications, with copies of testimonials, should be made in writing to the ASSISTANT SECRETARY, Establishment Department, Board of Trade, Great George-street, S.W.1, not later than 18th June, 1938. 4721

War Department.
CIVILIAN INSTRUCTOR REQUIRED for the Royal Army Service Corps Training Centre, Aldershot. Post is pensionable, subject to a period of satisfactory probation.

Candidates should preferably (A) be between the ages of 30 and 45 years, (B) have had recent experience in engineering and in teaching mathematics, chemistry and allied subjects up to the standard necessary for the examination for Associate Membership of the Institution of Mechanical Engineers, (C) possess recognised engineering qualifications, such as the A.M.I. Mech. E., or an honours degree in engineering from a British University.

Salary scale £400 a year, rising by annual increments of £18 to £500 a year.

Preference given to ex-Service candidates, other things being equal.

Application forms obtainable by postcard from the UNDER-SECRETARY OF STATE (C.5), The War Office, London, S.W.1, to be lodged not later than 15th June, 1938.
Quote Appts. 92. 4742

PUBLIC NOTICES.

Royal Army Ordnance CORPS.
APPLICATIONS are INVITED from qualified Mechanical Engineers or Electrical Engineers with a good knowledge of Mechanical Engineering, for COMMISSIONS in the ROYAL ARMY ORDNANCE CORPS.

Candidates must be between the ages of 23 and 27 years, and must have had practical Workshop Experience with approved Engineering Firms of at least three years' total duration, either as Pupils or Apprentices, or in an equivalent form.

In addition, they must either be Whitworth Scholars, have an Engineering Degree of any British University, or have passed the Graduateship Examination for either the Institution of Mechanical Engineers, or the Institution of Electrical Engineers, or have qualifications exempting them from these examinations. Electrical Engineers will not be considered unless they have an adequate knowledge of Mechanical Engineering.

All candidates will be required before final selection to attend at the War Office for a personal interview.

The total emoluments at present in force are approximately from £420 to £1265 per annum, according to service and rank.

Forms of application and full conditions can be obtained on application to the UNDER-SECRETARY OF STATE (A.G.9), The War Office, London, S.W.1. 4719

War Department.
STAFF FOR SCIENTIFIC RESEARCH.
APPLICATIONS are INVITED from adult male candidates for the undermentioned APPOINTMENTS. Successful candidates would be posted in the first instance to the Chemical Defence Experimental Station, Porton, near Salisbury, Wiltshire.

TECHNICAL OFFICER.

Mechanical Engineer required, with experience in modern workmanship practice and production methods. Candidates should preferably have a University Honours Degree in Engineering or its equivalent.

SALARY SCALE.—Normal, £275 by £18 to £455, and thence by £25 to £580 a year (efficiency bar at £455). Higher commencing salary up to £455 may be approved according to qualifications and experience.

ASSISTANT, I.

Applicants must have several years' research and/or industrial experience in chemistry and must be capable of supervising the operation of chemical plant and of designing modifications thereto without supervision. Experience in one or more of the following subjects is desirable:—(i) Synthetic plastics, (ii) paints, (iii) pyrotechnics. Possession of a University Degree in Chemistry or equivalent qualification is desirable.

SALARY SCALE.—£400 by £18 to £575 a year.

Increments in these posts are granted annually, subject to approved service.

The appointments are not pensionable and are approved for a limited period in the first instance. Promotion and/or appointment to a pensionable post is governed by suitability and merit as and when vacancies arise.

Ex-Service candidates given preference, other things being equal.

Application forms obtainable by postcard from the CHIEF SUPERINTENDENT, Chemical Defence Research Department, 14, Grosvenor-gardens, London, S.W.1, to be lodged with copies of not more than three recent testimonials not later than 14th June, 1938. 4741

War Department.
MECHANICAL DRAUGHTSMEN REQUIRED. Pay up to £5 5s. a week, according to qualifications and experience. Minimum age 23 years.

Prospects of promotion to higher posts governed by merit as vacancies occur. Present posts are non-pensionable, but a suitably qualified entrant will be eligible for consideration for appointment to the pensionable establishment, should vacancies arise. In any case, appointments will probably last for at least two to three years.

Candidates should possess the Higher National Certificate (Mechanical Engineering) or equivalent qualification, and should have had Workshop Experience and Drawing-office Experience, preferably in the Preparation of Designs and Working Drawings of any of the following:—
Gun Carriages and Mountings.
Guns and Mechanisms.
Ammunition Stores.
Tanks and Armoured Fighting Vehicles.
Commercial Vehicle Chassis or Trailers.
Small Intricate Mechanical Mechanisms.
Jigs and Tools.

Application forms obtainable by post card from CHIEF SUPERINTENDENT OF ORDNANCE FACTORIES (Advt. No. 217), Royal Arsenal, Woolwich, S.E.18. 4533

PUBLIC NOTICES (continued)
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The Engineer

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Entered as second-class matter at the Post Office, New York, N.Y., December 12th, 1896, under the Act of March 3rd, 1879 (Section 397, P.L. & R.).

*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next due, June 24th.

ADVERTISEMENTS.

The charges for Classified Advertisements is 1/- per line up to one inch—minimum chage 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

Postal Address, 28, Essex-street, Strand, London, W.C.2. Teleg. Address, "Engineer Newspaper, Estrand, London." Tel., Central 6565 (10 lines).

PUBLIC NOTICES.

PATENTS AND DESIGNS ACTS, 1907 TO 1932.

Notice is Hereby Given that

ARTHUR CROFT, of Buckstone Hall, Rawdon, near Leeds, in the County of York, SEEKS LEAVE to AMEND the SPECIFICATION of LETTERS PATENT No. 462,625, granted to him for an invention entitled "Change Speed Driving Gear."

Particulars of the proposed Amendment were set forth in No. 2576 of the Official Journal (Patents), published on 1st June, 1938.

Any person, or persons, may give Notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton-buildings, London, W.C.2, within one calendar month from the date of publication of the said Journal.

M. F. LINDLEY,
Comptroller-General.

P1343

University of Birmingham.

APPOINTMENT OF LECTURER IN DEPARTMENT OF CIVIL ENGINEERING.

APPLICATIONS are INVITED for the POST of LECTURER in CIVIL ENGINEERING. Commencing stipend at the rate of £400 per annum. Duties to begin October 1st, 1938. Candidates must hold a University Degree and have had practical experience, preferably in Structural Steel or Concrete. They must be prepared to undertake research. Four copies of application, with testimonials or references, must be sent on or before June 24th to the undersigned, from whom further particulars may be obtained.

C. G. BURTON,
Secretary.

June, 1938. 4750

County Council of Durham.

EDUCATION DEPARTMENT.
STOCKTON-ON-TEES TECHNICAL SCHOOL AND EVENING INSTITUTE.

APPLICATIONS are INVITED for the POST of GRADUATE ASSISTANT in ELECTRICAL ENGINEERING. Applicants should possess a good Honours Degree and have had some experience in teaching. Practical experience in Industry will be an additional recommendation. Salary will be paid in accordance with the Burnham Award for Technical Schools. Allowance will be made for Teaching and/or Industrial Experience.

A form of application (which must be returned duly completed not later than 17th June, 1938) can be obtained from the Director of Education, Shire Hall, Durham, on receipt of a stamped, addressed foolscap envelope.

THOS. B. TILLEY,
Director of Education.

Shire Hall, Durham. 4640

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P1257

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For full information and prospectus apply to the SECRETARY, King's College, Strand, W.C.2. Tel., Temple Bar 5651. 4758

Sudan Government.

The Director of Education invites APPLICATIONS for the POST of LECTURER in MECHANICAL ENGINEERING in the School of Engineering at Khartoum. Candidates should be between the ages of 24 and 28, unmarried, should have a University Degree in Mechanical Engineering, preferably of Honours standard, and have passed the Examination (or an examination qualifying for exemption) for Associate Membership of the Institution of Mechanical Engineers. Commencing salary £E.480 (or £E. 540, according to experience and qualifications), rising by biennial increments to a maximum of £E.1080 after eighteen years' service (£E.1 equals £1 0s. 6d.).

The selected candidate will not be required to take up his duties in Khartoum before 1st September, 1938.

Further particulars are obtainable from the UNIVERSITY APPOINTMENTS BOARDS, or from CONTROLLER, Sudan Government London Office, Wellington House, Buckingham-gate, S.W.1, to whom applications should be submitted not later than 1st July, 1938. Envelopes should be marked "Lecturer in Engineering." 4563

The Sir John Cass Technical Institute.

JEWRY-STREET, ALDGATE, LONDON, E.C.3.

DEPARTMENT OF METALLURGY.

The Governors of the Institute invite APPLICATIONS for the POST of LECTURER in METALLURGY.

Honours Degree or its equivalent desirable, preference being given to candidates with Works Experience or who have done Research.

Salary in accordance with the Burnham (Technical) Scale for London.

Details of the duties, to commence September, 1938, and form of application may be had from the undersigned. Applications, together with copies of three recent testimonials, to be forwarded not later than Saturday, June 18th.

GEO. PATCHIN,
Principal.

4743

Woolwich Polytechnic, S.E.18.

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT.

Head of Department: W. A. SCOBLE, D.Sc., M.I. Mech. E., Assoc. M. Inst. C.E.

APPLICATIONS are INVITED for TWO LECTURERS to commence duties on the 1st September. Salary up to £528 per annum, according to Teaching, Research, and Industrial Experience. Preference will be given to candidates who can qualify to become recognised teachers of the University of London.

Particulars of the appointments and forms of application may be obtained from the SECRETARY, on receipt of a stamped addressed envelope.

Closing date, 17th June. 4737

PUBLIC NOTICES.

Borough of Beckenham.

TO HEATING ENGINEERS.

The Council of the Borough invites TENDERS for the HEATING and ENGINEERING WORK required in connection with a new Clinic at Hawes Down Schools, West Wickham.

The Works include the provision of Boiler, Circulating Pipes, and Radiators for Heating the Building, and the provision of a Domestic Boiler and Hot Water Supply Pipes.

Copy of drawing, together with specification and form of Tender, may be obtained on application to Mr. P. Parr, B.Sc., A. M. Inst. C.E., Borough Engineer and Surveyor, Town Hall, Beckenham, on payment of a deposit of £2 which will be returned on receipt of a bona fide Tender not subsequently withdrawn.

Tenders must be enclosed in sealed envelopes, endorsed "Tender for Heating, Clinic Building," but not bearing any name or mark indicating the sender, and addressed and delivered to the undersigned not later than 12 o'clock Noon on Wednesday, June 15th, 1938.

No Tender received after the prescribed date and time will be considered, and the deposit will not be refunded unless a bona fide Tender is received by the due date and time.

The Council does not bind itself to accept the lowest or any Tender.

C. ERIC STADDON,
Town Clerk.

Town Hall,
Beckenham, Kent.
26th May, 1938. 4700

Cornwall County Council.

ROAD-MAKING PLANT.

TENDERS are INVITED from manufacturers for the SUPPLY of all or any of the following NEW ROAD-MAKING PLANT of British manufacture:—
CONCRETE MIXERS.
BITUMEN SPRAYERS and BITUMEN BOILERS.
COMPRESSED AIR ROCK DRILLS.

Further particulars may be obtained on application in writing to the County Surveyor, County Hall, Truro.

Tenders, in envelopes endorsed "Tender for Road-making Plant," but not indicating the senders, should be delivered to the undersigned not later than the 16th June, 1938. A decision thereon will be given within two months after the last day for the receipt of Tenders.

T. A. H. SHEERS,
Clerk of the County Council.

County Hall, Truro.
31st May, 1938. 4744

County Council of Middlesex.

WEST MIDDLESEX COUNTY HOSPITAL, ISLEWORTH.

The County Council invite TENDERS for the SUPPLY and INSTALLATION of HEATING SERVICES (by means of Hot Water Radiators and Coils), DOMESTIC HOT WATER and GAS SERVICES in connection with the modernisation of six Blocks of Existing Buildings at the West Middlesex County Hospital Extension, Tooilands-road, Isleworth.

Applications must be made to the undersigned by Noon, Monday, the 13th June, 1938, and must be accompanied by a deposit of £2 2s., payable by crossed cheque in favour of the Middlesex County Council and returnable on receipt of a bona fide Tender. Plans and conditions of contract may be inspected at the office of the County Architect, 10, Great George-street, Westminster, S.W.1, who will subsequently issue the drawings and specification, &c.

No Tender will be received except in a plain sealed envelope, which must not bear any name or mark indicating the sender and which must be marked "Tender, West Middlesex County Hospital Extension: Heating Installation." Tenders should be addressed to the undersigned and received not later than Noon on Monday, 4th July, 1938.

Only contractors of repute who are able to satisfy the Council of their ability to carry out the work in an efficient manner should apply. The Council do not bind themselves to accept the lowest or any Tender.

C. W. RADCLIFFE, "D.2,"
Clerk of the County Council.

Guildhall, Westminster, S.W.1.
Date, 30th May, 1938. 4753

London County Council.

TENDERS INVITED for the PROVISION INSTALLATION of ONE LANCASHIRE STEAM BOILER and FITTINGS, &c., at St. Nicholas' Hospital, Plumstead, S.E.18.

Specification, form of Tender, &c., obtainable from Chief Engineer upon payment of £1 by crossed cheque or order payable to London County Council. (NOTE.—CASH WILL NOT BE ACCEPTED.)

Amount returnable only if bona fide Tender is submitted and not subsequently withdrawn. Particulars of work obtainable on personal application, and contract documents may be inspected before payment of fee.

Remittances by post should be addressed to the Chief Engineer (B), County Hall, Westminster, S.E.1. Personal inquiries at Room 549 D.

Contractors will be bound to observe the provisions of a fair wages clause, terms of which are set out fully in the instructions for Tender, form of contract, and the "London County Council Gazette."

No Tender received by CLERK OF THE COUNCIL at County Hall after 4 p.m. on Tuesday, 21st June, will be considered. 4717

Meanwood Park Colony, Leeds.

SUB-CONTRACT ENGINEERING WORKS.

Firms wishing to be invited to TENDER for the above WORKS, which will comprise of the Installation of Steam Boilers, Laundry Equipment, Kitchen Equipment, and Heating and Domestic Hot Water Apparatus in various Types of Buildings now being erected, are requested to send their names and addresses, together with a list of similar works, stating the value thereof, which they have recently carried out. It is anticipated that the execution of the Works will occupy approximately three years, and that the Work will begin in or about August, 1938.

All applications will be considered by the Leeds City Council, and the plans and specification will in due course be issued for the preparation of Tenders by the firms selected from amongst the applicants.

Applications must reach the EXECUTIVE OFFICER, City of Leeds Mental Health Services Committee, 27, Blundell-street, Leeds, 1, not later than the 15th June, 1938. 4709

Metropolitan Water Board.

TO PUBLIC WORKS CONTRACTORS.

The Metropolitan Water Board intend to invite TENDERS for the CONSTRUCTION of a Large STORAGE RESERVOIR in the Thames Valley in the immediate future, and are prepared to consider applications from Contractors to be placed on a list of selected firms who will be invited to submit Tenders.

The Reservoir will be situated immediately to the South of the existing Knight and Bessborough Reservoirs at Walton in the Urban District of Walton and Weybridge, and the Urban District of Esher, in the County of Surrey. It will have a capacity of about 4400 million gallons and cover an area of 374 acres.

The Reservoir will be formed of a Continuous Earthen Embankment containing approximately 3¼ million cubic yards with a Central Clay Puddle Core carried down through Water-bearing Strata into the London Clay.

Firms applying to be placed on the selected list should submit full particulars of contracts for works of a similar character and magnitude which they have carried out, and also furnish financial references.

Applications should be address d to the Chief Engineer, Metropolitan Water Board, 173, Rosebery-avenue, E.C.1, and be delivered not later than 10 a.m. on Friday, 1st July, 1938.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board:
173, Rosebery-avenue, E.C.1.
27th May, 1938. 4724

PUBLIC NOTICES.

Metropolitan Water Board.

HAMPTON WORKS.—MAINS.

The Metropolitan Water Board invite TENDERS for the LAYING of STEEL MAINS and CONNECTIONS of various diameters up to 66in., together with the CONSTRUCTION of about 250 LINEAL YARDS of STEEL-LINED CONCRETE CONDUITS of 60in. and 78in. diameter at their Hampton Works, Lower Sunbury-road, Hampton-on-Thames, in the County of Middlesex.

The drawings and contract documents may be inspected without charge at the offices of the Board, Chief Engineer's Department (Room 201).

Forms of Tender, conditions of contract, specification, and bills of quantities, together with drawings and a spare copy of the bills of quantities, may be obtained on and after Monday, 13th June, 1938, from the Chief Engineer, on production of an official receipt for £10, which sum must be deposited with the Comptroller to the Board and which will be returned on receipt of a bona fide Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the bills of quantities, which may be retained by the tenderer). Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Mains, Hampton Works," must be delivered at the offices of the Board (Room 122) not later than Twelve o'clock Noon on Tuesday, 5th July, 1938.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C.1,
28th May, 1938. 4725

Metropolitan Water Board.

HAMPTON WORKS.—ASH BUNKERS.

The Metropolitan Water Board invite TENDERS for the CONSTRUCTION of REINFORCED CONCRETE ASH BUNKERS, approximately 35ft. by 16ft. by 30ft. high, and a MAKE-UP WATER TANK, approximately 19ft. by 16ft. by 9ft. high, together with a CONCRETE ACCESS ROAD, approximately 60 yards long, at their Hampton Works, Lower Sunbury-road, Hampton-on-Thames, in the County of Middlesex.

The drawings and contract documents may be inspected without charge at the offices of the Board, Chief Engineer's Department (Room 201).

Forms of Tender, conditions of contract, specification, and bills of quantities, together with drawings and a spare copy of the bills of quantities, may be obtained on and after Monday, 13th June, 1938, from the Chief Engineer on production of an official receipt for £10, which sum must be deposited with the Comptroller to the Board and which will be returned on receipt of a bona fide Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the bills of quantities, which may be retained by the tenderer). Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Ash Bunkers, Hampton Works," must be delivered at the offices of the Board (Room 122) not later than Twelve o'clock Noon on Tuesday, 5th July, 1938.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C.1,
28th May, 1938. 4726

Spilsby Rural District Council.

FEN WATER SCHEME.
CONTRACT No. 9.

The Council invite TENDERS from competent Reinforced Concrete Contractors for the CONSTRUCTION of a SERVICE RESERVOIR (150,000 gallons capacity) near Spilsby.

Forms of contract and further particulars may be obtained from the undersigned on payment of a deposit of Two Guineas, which will be refunded on receipt of a bona fide Tender not subsequently withdrawn. Tenders must be delivered by Noon on Monday, 20th June, 1938.

T. H. E. COTTELL,
Clerk of the Council.

Spilsby, Lincs,
June 3rd, 1938. 4711

Spilsby Rural District Council.

FEN WATER SCHEME.
CONTRACT No. 10.

The Council invite TENDERS from competent Public Works Contractors for the LAYING of WATER MAINS and ANCILLARY WORKS in connection with the above Scheme.

Forms of contract and further particulars may be obtained from the undersigned on payment of a deposit of Two Guineas which will be refunded on receipt of a bona fide Tender not subsequently withdrawn. Tenders must be delivered by Noon on Monday, 20th June, 1938.

T. H. E. COTTELL,
Clerk of the Council.

Spilsby, Lincs,
June 3rd, 1938. 4710

City of Durban.

APPOINTMENT OF DEPUTY CITY AND WATER ENGINEER.

APPLICATIONS are INVITED for the POSITION of DEPUTY CITY and WATER ENGINEER for the City of Durban, Natal, South Africa. The grade for the position is £1500-£37 10s.-£1736-E, subject to the Council's Scheme of Deflation of Salaries and Wages. The appointment will be in terms of the Council's General Conditions of Service and Leave Regulations, and the commencing salary will be at the minimum of the grade.

Applicants must be under the age of 45 years.

The applicant must be a Corporate Member of the Institution of Civil Engineers, or possess a Degree in Civil Engineering.

The Departmental activities coming under the control of the City and Water Engineer at present include:—

PUBLIC WORKS, embracing Roads, Reinforced Concrete and Structural Steel Construction, Storm Water Drainage, Sewerage, Housing, Surveys, Town Planning, Beach Restoration, and General Development.
PARKS AND GARDENS, entailing Lay-out and Control of all Parks, Gardens, and Open Spaces.
BEACH MANAGEMENT, which includes Control of Bathing and General Pleasure Amenities.
STREET CLEANING AND CONSERVANCY, the executive side of Public Health Arrangements dealing with Street Cleaning, Night Soil and Rubbish Removals and Cemeteries.
WATERWORKS, including the Administration of all Works and Estates pertaining to Water Supply.

The successful applicant will be required to undergo a medical examination by a nominee of the Council.

Applications, stating age, qualifications and experience in full, and accompanied by COPIES of not more than three testimonials and supporting documentary evidence of qualifications and satisfactory state of health, must reach the office of the Town Clerk, Durban, South Africa, not later than Friday, 15th July, 1938.

Personal canvassing for the appointment is prohibited and proof thereof will disqualify a candidate, vide Council's Standing Order No. 1.

E. B. SCOTT,
Town Clerk.

Town Clerk's Office,
Municipal Buildings,
Durban,
11th May, 1938. 4650

For continuation of Small Advertisements see page 4.

A Seven-Day Journal.

Atmospheric Pollution.

A CONFERENCE, which closed on Tuesday, May 31st, of representatives of local authorities and other organisations co-operating with the Department of Scientific and Industrial Research in investigations into the nature and extent of atmospheric pollution, dealt with the progress made during the past six months. It noted that during the ten years which had elapsed since its first meeting there had been a marked increase in the number of places at which observations of deposited, and of suspended matter, were being regularly made by co-operating bodies, and that, in addition, a continually growing number of regular observations were now being made of sulphur gases in the atmosphere by methods which had since been introduced. The conference expressed its strong belief in the importance of continuing and extending the investigation in order to provide the assured basis of fact necessary for determining the nature of remedial measures desirable and for estimating their effect, when introduced. Dr. G. M. B. Dobson, F.R.S., Chairman of the Atmospheric Pollution Research Committee, presented a report on the progress of the investigations carried out under the Committee. He dealt first with the work in progress at the special survey of atmospheric pollution in and around Leicester. Routine measurements had been systematically made for a year over a considerable area, to obtain information about the behaviour of pollution under various weather conditions. It was proposed to continue those measurements for a further year at least. The work of the Survey also included tests under practical conditions of new types of instrument and research on methods of measurement. Dr. Dobson also referred to the valuable results which were already apparent from a conference of technical representatives of co-operating bodies which had been held in March to discuss in detail methods of measuring atmospheric pollution. The suggestions made were being considered by the Research Committee.

British Motor Vehicle Industry.

WE have received from the Society of Motor Manufacturers and Traders, Ltd., of 83, Pall Mall, S.W.1—and, from June 30th, Hobart House, Wilton-street, S.W.1—a copy of the Home Market Analysis, 1938, No. 12, which is obtainable from the secretary at the price of one guinea. This book is claimed to be the most complete analysis of the United Kingdom motor market in existence. Every individual horse-power, unladen weight, and seating capacity class in each of the 180-odd licensing districts is analysed, covering motor vehicles in use, as well as new sales. For comparative purposes, statistics for previous years are also given. An entirely new section is included dealing with the life history of a private car and in this connection tables are given showing the probable expectation of life and the death-rate at any age. It is shown that the average life of a private car in this country is 7·6 years. Special sections deal in detail with Eire, Jersey, and Guernsey. A point of interest in these three areas, as with Northern Ireland, is that tables are included giving registrations by makes. From a forecast included in the publication we note that the Statistical Department estimates that by September, 1938, the number of private cars on the roads of the United Kingdom will amount to 1,970,000—an increase of 136,000 over 1937—and the total number of mechanically propelled vehicles will exceed 3,000,000. Information of particular interest, especially to those concerned with market potentials, will be found in a table which gives the number of motor cars in use per 1000 persons for every licensing area in the United Kingdom. The analysis contains in all fifty-two tables.

Generation of Electricity in Great Britain.

THE returns made to the Electricity Commissioners of units generated and fuel consumed at generating stations in Great Britain during the year ended December 31st, 1937, cover 424 stations which were generating during 1937, a decrease of 18 on the number included in the previous returns. The total amount of electricity generated at the 424 stations during 1937 was 24,314,845,292 units, an increase of 12·31 per cent. on the corresponding figure for 1936. Of the units generated, the proportion used on works was in the neighbourhood of 5·4 per cent. The total amount of fuel consumed was 14,977,191 tons of coal and coke, an increase of 8·6 per cent., and fuel oil 23,949 tons, as compared with 24,043 tons in 1936. In group A, covering stations generating over 200 million units, the Battersea station of the London Power Company had a thermal efficiency of 27·7 per cent., which is the highest recorded. At the Dunston B station, a thermal efficiency of 27·38 per cent. was secured, and at the Barking B station of the County of London Electric Supply Company, 26·33 per cent Fulham showed 25·7 per cent., the Kearsley station of the Lancashire Electric Power Company 24·70 per cent., the Clarence Dock station of the Liverpool Corporation 25·34 per cent., the Barton station of the Manchester Corporation 20·55 per cent, the new Blackburn Meadows station of the Sheffield Corporation 22·4 per cent., the Tir John North station of the Swansea Corporation 20·78 per cent., the Ironbridge station of the West Midlands Joint Electricity Authority 25·03 per cent., the Thornhill station of the Yorkshire Electric Power Company 22·93 per cent., and the Hams Hall station of the Birmingham Corporation 21·42 per cent. In group B, covering stations sending out 100–200 million units, Hackney tops the list with 21·20 per cent.; and in group C, relating to 50–100 million unit stations, the Derby Corporation leads with a thermal efficiency of 19·47 per cent.

Trend of Invention.

IN the fifty-fifth report of the Comptroller-General of Patents, Designs, and Trade Marks, for the year 1937, reference is made to the trend of invention. The report states that the year was notable for the high level of activity which was displayed in all fields of invention. For the most part the advances made were in the direction of improvements in existing processes and apparatus. In the field of electric power, mention may be made of the quenching of arcs in high-tension switches by the employment of solid materials as linings to the arc chambers which give off gases having a deionising action. The technique of electric protective systems usual in electric power supply and distribution is being applied to small installations in order to meet the problems arising from the now relatively heavy loads employed. Air space insulated cables received much attention, as did also incandescent electric lamps in which the gases krypton and tenon are used as filling media. The falling-off in inventions relating to mercury arc rectifier systems continued. On the other hand, some activity is recorded in circuits for super high-pressure mercury vapour lamps. As regards aircraft, the principal fields of invention were those in connection with the de-icing of propellers and wings, and hydraulic operating gear for retractable undercarriages. The use of fluid pressure servo-motors for automatic control was pronounced in its applications not only to aircraft and motor vehicles, but also to power and industrial plant. Efforts to reduce the rolling and pitching of ships led to the filing of a number of applications. The number of applications for patents received during the year under review was 36,266, as compared with 35,867 in 1936.

Birmingham Aircraft Factory.

AT a meeting of the Birmingham City Council, held on Tuesday, May 31st, approval was given to the proposal to sell 130 acres of Corporation land at Tyburn to Morris Motors, Ltd., for an aircraft factory. The land in question was acquired by the Corporation from the Dunlop Rubber Company, Ltd., for housing purposes, and it adjoins Castle Bromwich Aerodrome, near to the British Industries Fair ground. During the discussion of the proposal it was disclosed that the factory proposed is not to be a part of the Government's Shadow Aircraft Factory Scheme, but a private enterprise for which Lord Nuffield has intimated that he will provide the sum of about £3,000,000. It is expected that the factory will find employment for close upon 15,000 people. The Public Works Committee of the Corporation was somewhat reluctant to agree to the disposal of the site, and it suggested an alternative site in the neighbourhood. Morris Motors, Ltd., however, was not prepared to consider that site, and mentioned a more suitable alternative site near Oxford. As the Corporation has now approved the sale, the Public Works Committee proposes to proceed with the negotiations on the understanding that the Corporation will incur no loss on the transaction. It is stated that work on the new factory is to begin at the earliest possible moment, and it seems probable that the new buildings will be ready for occupation in about six months' time.

Two Important Appointments.

ON Tuesday, May 31st, it was officially announced by the War Office that Dr. H. J. Gough, the Superintendent of the Engineering Department of the National Physical Laboratory, has been appointed to the new post of Director of Scientific Research at the War Office, which was forecast by the Secretary of State for War in his speech introducing the Army Estimates. Dr. Gough took up his new duties on Wednesday last, June 1st. As the Director of Scientific Research, he will be directly responsible to the Director-General of Munitions Production for the general direction and organisation of research work for War Office purposes; for advising as to the programme of research work to be undertaken and as to proposals for specific investigations; and for the efficiency of the organisation for research and experimental purposes of the various research organisations under the War Office. He will represent that Department on the various inter-departmental research organisation. . . . It was officially announced by the Lord President of the Council on Wednesday, June 1st, that Professor Ralph Howard Fowler, F.R.S., Plummer Professor of Applied Mathematics at the University of Cambridge, is to be Director of the National Physical Laboratory with effect as from October 1st next. Professor Fowler succeeds Dr. W. H. Bragg, who, as recorded in these columns, was recently elected to the Cavendish Professorship of Experimental Physics at Cambridge University. Professor Fowler was educated at Winchester College and Trinity College, Cambridge, where he was the recipient of many honours. During the war he served as Assistant-Director in the Anti-Aircraft Experimental Section of the Munitions Invention Department. He is the author of several treatises on Differential Geometry of Plane Curves, and Statistical Mechanics and of papers on External Ballistics and Theoretical Physics.

Engineering Unions and Rearmament.

A MEETING of representatives of engineering employers and the unions in the industry took place in London on Wednesday, May 25th, when questions relating to the acceleration of the rearmament programme and the more rapid production of aircraft were the subject of discussion. Sir Charles Craven, as Chairman of the Engineering and Allied Employers' Federation, presided, and Sir Alexander Ramsay, Director of the Federation, spoke on the requirements of the employers. The position of the unions was outlined by Mr. J. C. Little for the Amalgamated Engineering Union, and by Mr. M. Hodgson, secretary of the Boilermakers' Society. We understand that the proposals submitted by the employers did not envisage any change in the practice of works, but suggested that shortage of skilled labour in one trade might be supplemented temporarily by skilled labour from another trade, and that where skilled labour was not available semi-skilled labour might be employed. It was also considered that there was a possible opportunity for women in jobs for which they might be fitted. Further comment on these proposals was made by Mr. J. C. Little at a meeting of the National Committee of the Amalgamated Engineering Union, which took place at Morecambe on Tuesday, May 31st. After discussion, a resolution was finally adopted which declared that the union would not tolerate any interference with its rights and privileges, as it believed that any form of dilution of labour was unnecessary and had not been justified.

Fuel Research.

THE Fuel Research Station at Greenwich was visited on Tuesday, May 31st, by over 300 representatives of science and technology from all parts of the country. The visitors were received by the Director of Fuel Research, Dr. F. S. Sinnatt, F.R.S. Exhibits were on view showing the development of the coal survey which is being carried out at the Fuel Research Station in collaboration with nine other laboratories in the principal coalfields. Another investigation of interest is the precise information which is being obtained with regard to the burning of coal in the ordinary domestic grate. Results indicate that smoke emission depends on many factors, such as coal quality and size, the relative proportion of air entering below and above the fire, and the design of the fire and grate. Work is being done on the conversion of motor lorries fitted with petrol engines to producer gas generated from solid fuels. Two vehicles were shown, a 1-ton and a 5-ton lorry, the first fitted with a producer of British make and the other with a special producer designed by the Fuel Research Station with a view to studying a form of construction adaptable for a wide range of fuels. The production of motor spirit and fuel oil by the synthesis of carbon monoxide and hydrogen is still being studied. The water-gas plants at the Station have been modified to use coal instead of coke and weakly caking coals have been successfully gasified. A particularly interesting demonstration was given showing how the dust raised in the handling of coal can be largely reduced by spraying the coal with a small quantity of oil. Reference to fuel research was made by Mr. H. C. Smith, Chief Engineer to the Tottenham and District Gas Company, in his presidential address to the Institution of Gas Engineers on Tuesday last. The Council of the Institution had, he reported, explored the conditions under which financial aid could be obtained from the Department of Scientific and Industrial Research.

Voltage Regulators.

No. IV.

(*Continued from page 585, May 27th.*)

THE operation of the Metropolitan-Vickers vibrating contact voltage regulator, type V C, Fig. 22, will be understood from Fig. 23, which represents diagrammatically a three-phase alternator A with a direct-coupled shunt-wound exciter E, connected as it would be if one or two machines were working in parallel on load, each under the control of a separate automatic regulator. A cam T is rotated by a single-phase, shaded pole, ball-bearing induction motor, deriving its supply from the transformer K. The

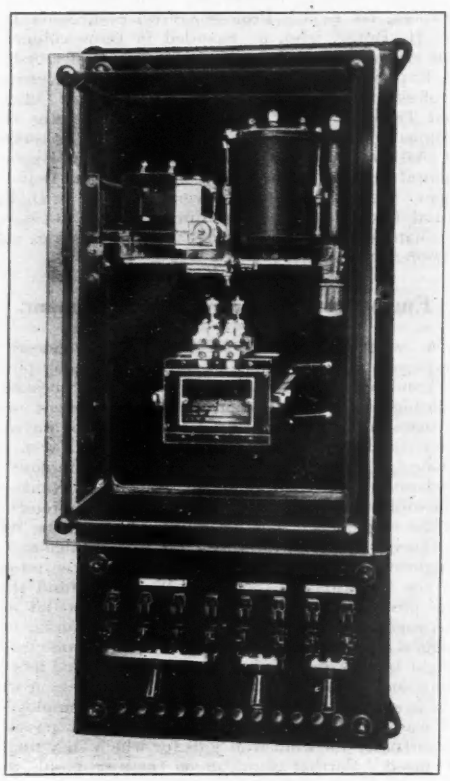


FIG. 22—METROPOLITAN-VICKERS VIBRATING CONTACT REGULATOR

rotation of the cam causes the contact W to move up and down with constant frequency and amplitude. At X is a spring-supported contact which engages with the contact W, except when its upward movement is arrested by a stop on the main control arm Q. This control arm carries an iron core I, free to move up and down inside a coil energised from the potential transformer K and in the coil there is also a fixed iron core V.

The contacts M are connected across the exciter

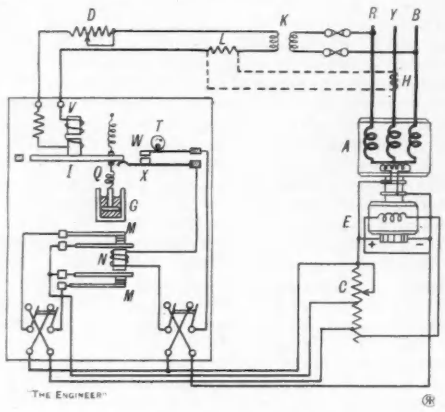


FIG. 23—DIAGRAM OF REGULATOR

field resistance C and close under the influence of a spring, except when the coil N is energised. During normal operation the contacts W and X are making and breaking at the rate of about eight times per second, and the contacts M are therefore performing the same operation. Thus as in the case of the other vibrating contact regulators described, the resistance C is alternately put into circuit and short circuited, and its average value depends on the time during which the contacts M are closed.

A drop in voltage results in a reduced upward pull on the moving iron I and the control arm Q therefore moves downwards with the result that the contacts W and X are held open for a longer period and the contacts M therefore close for a longer time. This reduces the effective resistance of C, thus bringing up the excitation until the voltage is restored sufficiently to arrest the downward movement of Q. An oil-filled dashpot G prevents the control arm Q moving too far before the machine can respond to the

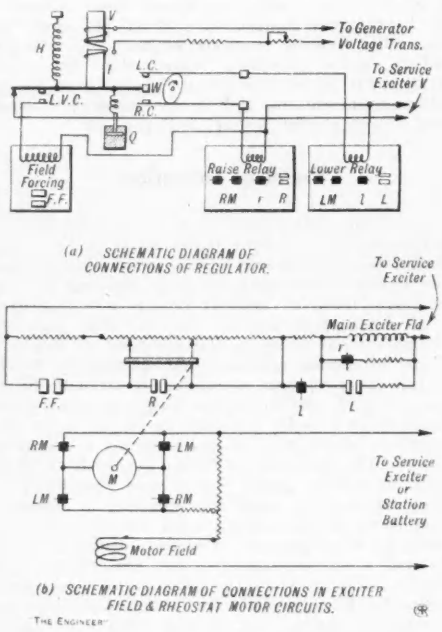


FIG. 24—DIAGRAMS OF M.V. "QUIESCENT" REGULATOR

change in the effective resistance of the rheostat, and as the dashpot piston is connected to the control arm by a spring, rapid movement of the arm independently of the dashpot is prevented in the event of any appreciable disturbance in the voltage. D is the regulator control coil rheostat, H a current transformer, and L a compounding resistance. The connections shown in dotted lines from the current transformer are for ensuring stable operation of two or more automatic regulators, controlling machines operating in parallel. The voltage across the resistance L is of such polarity that if the generator current

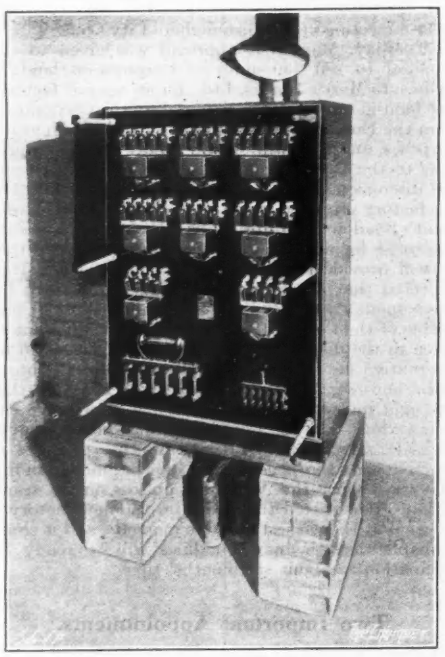


FIG. 25—B.T.H. CONTACTOR PANEL

tends to lag unduly the current in the regulator control coil is increased and the regulator therefore reduces the generator excitation.

Where for reasons of economy it is desirable not to install more than one automatic regulator, an alternative arrangement may be adopted provided that the exciters are all stable down to no-load excitation and that the total of the exciter field circuits is not beyond the capacity of one automatic regulator. This arrangement involves the provision of a separate set of controlling contacts on the automatic regulator for each exciter. These contacts are connected in parallel with a block resistance connected in series with the hand-controlled exciter rheostat. During automatic regulation the hand-controlled exciter rheostats are normally fully raised, and are thus available for balancing the power factors on the parallel running generators by manual adjustment when necessary. The arrangement is quite satisfactory when the exciters have reasonably similar characteristics, or when occasional hand adjustment is not an objection. It is not recommended, however, except on small generators where accurate balance of power factor is relatively unimportant.

The Metropolitan-Vickers' "quiescent" or rheostatic regulator, type V S, has been developed primarily to control large base load generators subjected to infrequent load changes of a minor nature, but demanding quick variation of excitation under abnormal conditions, such as when faults occur or when a fault has been cleared and the generator is left with a greatly reduced load or left charging transmission lines with next to no power load. By reason of the wide momentary variation characteristics of water turbines, this line-charging condition becomes even more important. On large machines the exciter field circuits are usually excited from a constant voltage machine in the manner described, and in order to obtain a measure of field forcing, the voltage of this machine is considerably higher than that necessary for the steady full kVA condition. As a result, both the range of field current and the ohmic value of the resistance to be regulated are large compared with the corresponding values for earlier designs of shunt-excited exciters for smaller alternators.

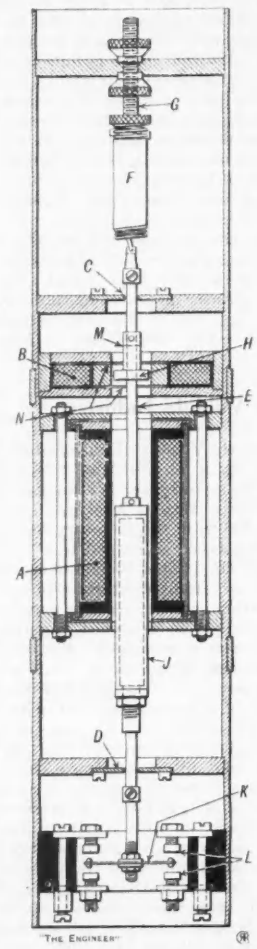


FIG. 26—SECTION OF B.T.H. RELAY

The apparatus under consideration operates in conjunction with a motor driven field rheostat, which is made to "follow up" the action of the regulator after each correction of excitation so that the controlling contacts of the regulator are at rest under steady conditions of load and frequency. The operating mechanism of the M.V. "quiescent" equipment is similar to that of the vibrating contact regulator previously described. The two diagrams in Fig. 24 show the connections of the regulator coil and the controlling contacts to the exciter field circuit and rheostat motor. In Fig. 24*a*, V and I are the fixed and moving cores respectively in a coil connected through a voltage transformer to the terminals of the machine under control. The upward magnetic pull on the moving core and the tension on the spring H are so adjusted that the weight of the former together with that of the other moving parts is just balanced at normal voltage in any position between its limits of travel. The moving core I is supported on a control lever carrying the contact W, the movement of which is damped by the spring coupled dashpot Q. Contacts L C and R C are made to move up and down by the rotation of a cam as on the V C Metropolitan-Vickers regulator, their movement being such that they approach but do not quite touch the contact W when the latter is in the mid-position. But a fall of machine voltage causes contact W to engage with R C and the duration of contact is sufficient to cause the voltage to be restored by the intermittent impulsing of contacts R and *r*, Fig. 24*b*. At the same time, the impulsing of contacts R M, connected in the rheostat motor circuit, slowly raises the rheostat until the automatic regulator contacts are again in the inactive position. A rise in machine voltage is corrected in a similar way by the intermittent closing of contacts W and L C (Fig. 24*a*), resulting in the impulsing of the contacts L *l* and the rheostatic lowering contacts L M. When the full range of exciter field current is greater than that which

can be conveniently placed under control of the normal lowering and raising contacts, a field forcing contactor F F is used with its coil energised by a low-voltage contact L V C (Fig. 24*a*) on the automatic regulator. The contacts F F of the field forcing contactor are connected so as to apply the full voltage of the service exciter to the main exciter field in the event of an abnormally low voltage.

In some cases it is more convenient to operate the field forcing contactor by a separate low-voltage relay, the setting of which is independently adjusted without affecting the normal adjustment of the automatic regulator. Usually this relay is set to close contact at 80 per cent. of normal voltage and to reopen just before the normal voltage is restored. Voltage regulators of this type have been installed in the Battersea power station for regulating the

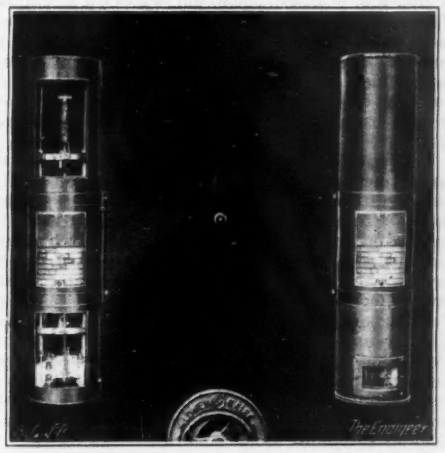


FIG. 27—RELAY MOUNTED ON SWITCHBOARD

80,000 and 125,000-kVA Metropolitan-Vickers machines.

In the B.T.H. "quiescent" regulator the primary control is carried out by a separate sensitive relay. Two relays are employed. One is calibrated to operate on a small variation of voltage and will therefore correct the voltage arising from all incidental load changes. The other relay is calibrated for a wider setting, usually ± 5 per cent., and operates only on sudden large changes of load or under fault conditions. The relay contacts actuate contactors and a panel of contactors, shown in Fig. 25, installed for the regulation of the 94,000-kVA turbo-generators supplied by the B.T.H. Company to the Barking power station. These contactors are divided into groups for raising and lowering excitation as determined by the finely set relay and for performing the same operations as determined by the coarsely set relay. A section of the relay is shown in Fig. 26 and Fig. 27 shows the complete relay equipment mounted in its case on the switchboard panel. As all the operating parts are mounted on a spring-

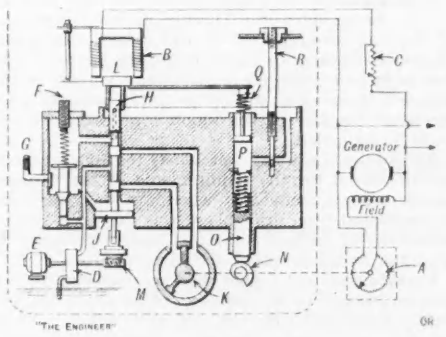


FIG. 28—DETAILS OF ISENTHAL REGULATOR

suspended central spindle, the friction of moving parts is eliminated.

The voltage sensitive feature consists of the relay coil A connected to the source of voltage to be regulated and the magnetic plunger J, mounted on a central spindle. The adjusting screw G of the suspension spring is arranged so that the number of coils of the spring in use can be varied to suspend the central spindle with its core and other attachments in a neutral position as indicated by the mark M. With an increase or decrease of the voltage to be regulated, the contacts K are moved upwards or downwards as the case may be and make electrical connection with the fixed contacts L. To avoid sparking and chattering of the contacts if the voltage so changes that the moving contacts K only make casual contact with the contacts L, a snatching magnet with an exciting coil B is provided. Except for two short gaps N the magnetic circuit of this magnet completely surrounds the coil.

The armature H of the snatching magnet is mounted on the central spindle, and when the moving contacts are in their mid position the armature is midway between the gaps N. But when the moving contacts have travelled to within, say, 0·05in. of the fixed contacts on either side, the armature of the snatching magnet has approached nearly to one of the openings in the magnetic circuit N with the result that as any further movement of this armature would tend to close and so perfect the magnetic circuit of the snatching magnet, the spindle experiences an upward or downward pull as the case may be. The moving contacts, consequently, rapidly approach and are held tightly against the fixed contacts.

In order that the relay contacts may not dwell upon one another when the generator voltage has been adjusted, each associated contactor has auxiliary fingers and when it is operated by current passing

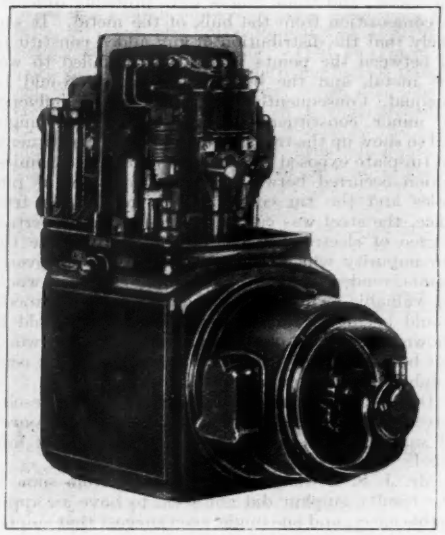


FIG. 29—ISENTHAL REGULATOR

through the relay contacts, in addition to those fingers which operate upon the circuit of the field rheostat motor, one auxiliary finger de-energises the snatching magnet, while another finger alters the resistance of the relay coil circuit, both effects tending to throw the moving contacts of the relay off the fixed contacts. In the case of the contactors associated with the more coarsely set relay, auxiliary fingers also short circuit the whole of the rheostat upon a voltage drop or reduce the exciter field current to a minimum upon a voltage rise, and for these conditions of regulation they also increase the speed of the rheostat motor.

Absence of vibrating contacts is one of the main advantages claimed for the automatic regulator shown in Figs. 28, 29 and 30, supplied by Isenthal and Co., Ltd., of Duncan Works, North Acton, W.3. It is made in various sizes to meet different requirements and to provide, if necessary, a particularly high operating speed and accuracy. The diagram, Fig. 28, shows a regulator applied to a D.C. generator, which might be an alternator exciter, although in that case the regulator would be fed through a potential transformer. The shunt regulator A is mechanically coupled to the operating mechanism. Control coils B are connected in the case of a D.C. generator across the machine terminals, and to ensure that the current through these coils is not influenced to an appreciable extent by temperature variations, a ballast resistance C having a negligible temperature coefficient is connected in series with them. Since this resistance is adjustable, it can be employed to adjust the regulated voltage. A valveless oil pump D is driven by a fractional horse-power motor E. The oil pressure is adjusted and subsequently maintained constant by a spring-loaded valve F.

While the driving motor is running the regulator can be rendered inoperative by turning an oil cock G, which reduces the pressure to a negligible value. The controlling magnet B operates directly or indirectly on a pilot valve H. Normally the pressure on this sleeve valve is balanced by opposing oil and spring pressures, but when the pilot valve is disturbed by a variation in the pull of the control coil, the main sleeve valve J is unbalanced and allows oil under pressure to pass into either side of a servo motor K, with the result that the wing of this motor moves the field rheostat A into a position which restores the generator voltage to normal, after which the valves return to their normal balanced position.

The armature L of the control magnet is very sensitive and small displacements are sufficient to disturb the oil flow through the pilot valve and initiate regulation. To obtain accurate regulation the pilot and main sleeve valves are made to rotate continuously by the worm wheel M and since the valves are efficiently lubricated by the oil under pressure friction is practically eliminated.

Another important feature is an overshooting limiting device, made necessary by the magnetic inertia of generators, especially alternators or very large D.C. generators operating with separate exciters. Although it is important that the rheostat should reach its new position as rapidly as possible, it is necessary to provide mechanism to slow up this rapid movement when this new position is approached. On the servo motor spindle, a cam N is therefore provided to operate a spring-loaded plunger O in an oil cylinder. The movement of this plunger applies a pressure to a light piston P connected through an adjustable spring coupling Q to the control armature in such a way that a pressure is applied on the armature L in opposition to the movement which initiated the servo-motor rotation. This "back pressure" is automatically varied by the extent and rapidity of the servo-motor movement, but can be adjusted by a by-pass valve R, so that the time constant of the regulator movement approximately corresponds to that of the machine. The arrangement also provides an efficient damper, which by suitable adjustment can be used to make the regulator sluggish to meet special requirements.

Other regulators of this kind of somewhat different design are available for the control of super power station generators, some giving considerable accuracy and speed of movement, whilst providing sufficient torque for the operation of several large rheostats.

The regulators can be fitted with additional control mechanism for the automatic reduction of the generator voltage if the normal load current should be considerably exceeded. A current coil in the case of alternators brings the rheostat into operation when a predetermined current is exceeded. Compensating windings may be provided to ensure the correct distribution of wattless load over several alternators running in parallel and compound windings to counteract voltage drop in long feeders. By modifying the control magnet by introducing a potential coil

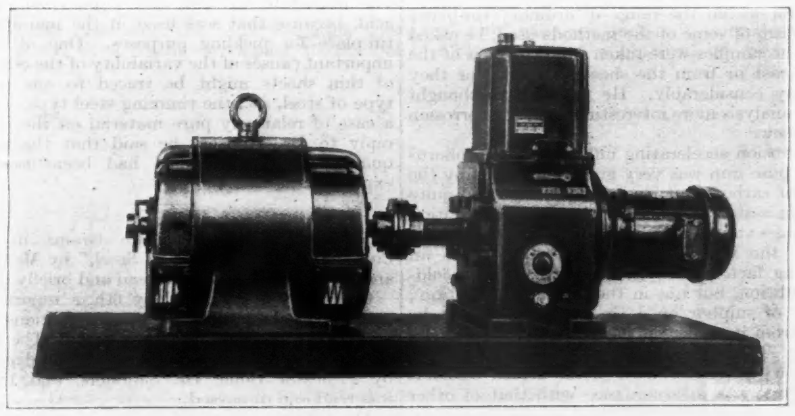


FIG. 30—ISENTHAL REGULATOR DRIVING AN INDUCTION REGULATOR

operating on a current coil connected so that the power current is in quadrature with the voltage, the regulator can be used for the regulation of a synchronous condenser or to control units of a bank of fixed condensers. Such a regulator can be designed to maintain unity power factor or any other power factor.

(To be continued.)

UNIVERSITY OF LEEDS.—The Council of the University of Leeds has elected Mr. D. T. A. Townend to the Livesey Chair of Coal Gas and Fuel Industries, to take office from October next, in succession to Professor J. W. Cobb. After nearly four years of war service, Professor Townend entered the East London (now the Queen Mary) College of London University. He graduated in 1920 and went to the Department of Chemical Technology at the Imperial College of Science, London, for post-graduate study and research under Professor W. A. Bone. He has since collaborated with Professor Bone more particularly in investigating gaseous explosions at high initial pressures. He has been largely concerned in the equipment and organisation of the high-pressure laboratories at the Imperial College.

The Iron and Steel Institute.

No. IV.

(*Continued from page 589, May 27th*).

Acid Attack on Mild Steel.

A PAPER entitled "The Influence of Composition and Treatment on the Rate of Acid Attack on Mild Steel," by Messrs. C. A. Edwards, F.R.S., D. L. Phillips, and D. F. G. Thomas, was also presented at the final session on Thursday, May 5th.

This investigation deals with the influence of phosphorus, carbon, sulphur, and copper on the rate of attack by 6 per cent. sulphuric and 2 per cent. citric acids on mild steels, both in the annealed and in the heavily cold-rolled conditions. The steels were made in quantities of about 24 lb. in a high-frequency induction furnace under carefully controlled conditions, and chill-cast in the form of thick plates suitable for rolling into packs of thin sheets, as in ordinary tin-plate practice.

Discussion.

Mr. J. H. Whiteley (Consett) drew attention to a statement in the paper that there was a general indication that cold rolling caused a slight acceleration of the rate of corrosion, and said he had noted from all the results at different temperatures that the rate of attack increased with time. Although the authors had not given macro- or micro-structures, he thought it fair to conclude that the structures of the ingots they had used had had finer crystals at the outside than at the centre, and he put forward the supposition that the rate of attack became greater as the crystals became greater. If that were so it explained why phosphorus increased the rate of attack; it altered the texture of the steel. Examination of the figures in the paper did not show definitely that cold rolling increased the rate of attack, at any rate in the first stages.

Towards the end of the paper he had sensed a lack of buoyancy. The authors had postulated that alumina particles were the cause of their troubles, and had given examples to show that alumina in cold-rolled steels increased the rate of attack in sulphuric acid, but in the case of the same steels in the annealed condition the position was almost exactly reversed. Again, they had said that Armco iron invariably contained tiny specks of alumina, but he had never yet seen an Armco iron containing alumina particles.

Dr. T. P. Hoar said the authors seemed to have been interested in specially made steels, many of which would be useless for ordinary tin-plate. He would have thought it would have been of more practical interest to have had the materials prepared in a manner similar to that of tin-plate; only one had a composition within the range of ordinary tin-plate. In a criticism of some of the methods used, he asked whether the samples were taken from the bars of the ingots as cast or from the sheets as rolled, for they might vary considerably. He would have thought the sheet analysis more interesting from the corrosion point of view.

The corrosion accelerating influence of phosphorus in nearly pure iron was very greatly modified by the addition of carbon, but its influence might be quite different in a steel of ordinary tin-plate composition with average values of sulphur, copper, and carbon. Similarly, the work showed that sulphur was an accelerating factor when the steel was in the cold-rolled condition, but not in the annealed condition; the effect of sulphur on a tin-plate steel might be different from its effect on the materials the authors had used. The conclusion that copper was on the whole a very potent retarder of the attack by acids on mild steel was in accordance with that of other workers.

As to the suggestion that the protective influence of carbon in their phosphorus steels was due to the formation of a layer of decomposed cementite on the surfaces, he said he had never seen such a layer on tin-plate, and he asked for further information.

His impression of the paper was that the results were of very great interest to the fundamental or academic worker, but of no immediate practical importance to the consumer or manufacturer of tin-plate; until the work could be done on average tin-plate composition, statistical analysis of results from commercial tin-plate materials would have more practical interest to the users and makers.

Mr. J. M. Bryan, discussing references to the variation of rates of corrosion of different specimens cut from the same sheet, said that in specimens cut from sheets obtained from a number of works in South Wales he had found that not only did the specimens cut from the same sheets agree very well, but there was good agreement between the different sheets from the same factory; there were slight consistent differences between materials from different factories. On the other hand, in other steel sheets, which he believed were imported, there were considerable differences between specimens cut from the middle regions and from near the edges, whereas there was very little difference between the edges and middles in the Welsh sheets.

Dr. U. R. Evans (Cambridge University) said that if the conclusions in the paper were intended to indicate the relative values of different varieties of steel in the canning of acid substances, such as fruit, it must be borne in mind that the steel of a tin canister was not exposed as a whole, but merely at certain places where the tin had failed to "wet" the metal, and those places were probably different in composition from the bulk of the metal. It was likely that the distribution of any added constituent as between the points where the tin failed to wet the metal, and the bulk of the metal, would be unequal. Consequently, experiments on the influence of minor constituents in uncovered steel might fail to show up the true influence of those constituents on tin-plate exposed to acid juices. Electro-chemical action occurred between the steel exposed at pin-holes and the tin covering. In general, in fruit juice, the steel was cathodic and received a certain degree of electro-chemical protection from the tin. An impurity which, concentrated at the uncovered points, rendered the steel still more cathodic, would be valuable, whilst one which rendered it anodic would be highly dangerous. That factor would be shown up only by electro-chemical tests, and would not be indicated by the rate of attack by 6 per cent. sulphuric acid upon bare steel.

Dr. J. C. Hudson, discussing some of the results, gave figures showing the effect of the degree of purity of sulphuric acid on the rate of dissolution of mild steel.

Mr. J. S. Lewis said that, judging from some of the results, sulphur did not seem to have an appreciable effect, and one might even suggest that sulphur had no effect provided a little copper was present.

Principal Edwards, replying to Mr. Whiteley, said he felt quite sure that alumina was almost invariably present in Armco iron. He agreed that the work should be extended by using ingots of commercial size, and then the material should be tinned and tested in collaboration with the Fruit Canners' Research Station. It was necessary to make the ingots in electric furnaces, however, in order to control the various elements within known limits.

In reply to Dr. Evans, he said that if the authors had used the word "corrosion" it was inadvertent; the work was specifically related to acid attack. He did not think the results of attack by 6 per cent. sulphuric acid, or even 2 per cent. citric acid, could have a direct bearing on the behaviour of food containers in practice. Nothing short of the fruit juices themselves could give really reliable data. But it was important to test with 6 per cent. sulphuric acid, because that was used in the manufacture of tin-plate for pickling purposes. One of the most important causes of the variability of the composition of thin sheets might be traced to one particular type of steel, *i.e.*, the rimming steel type, which had a case of relatively pure material on the ingot. In reply to Dr. Hudson, he said that the analytical quality of sulphuric acid had been used in the experiments.

A paper on "Martensitic Grains in Rapidly Cooled Ingot Iron and Mild Steel," by Mr. B. Jones and Mr. N. Gray, was then read and briefly discussed.

On Friday afternoon, May 6th, a report on "An Experimental Inquiry into the Interactions of Gases and Ore in the Blast-furnace: Part V, The Influence of Hydrogen and Steam at 450–850 deg. Cent.," by Professor Bone, Dr. Saunders, and Dr. Tress, was read and discussed.

The authors gave the following summary:—

GASES AND ORE IN BLAST-FURNACES.

The two main reactions occurring in the blast-furnace are (1) the catalytic decomposition of carbonic oxide, $2CO \longrightarrow C + CO_2$, at *circa* 450 deg. Cent., resulting in the deposition of carbon within and around the ore, and (2) the reduction of the oxides of iron, $Fe_2O_y + CO \longrightarrow Fe_2O_{y-1} + CO_2$, at higher temperatures. Data have been given in previous communications of the relative velocities of these reactions under varying conditions of temperature, CO_2 concentration, speed of gas flow, and degree of reduction of the ore, referred in all cases to a state of $CaCl_2$-dryness in the gas phase. Relative velocity measurements have now been extended to include the effects produced by additions of up to 2 per cent. of hydrogen and steam to blast-furnace gas over a temperature range of 450 deg. to 850 deg. Cent. The results show that both hydrogen and steam accelerate carbon deposition. Hydrogen also accelerates ore reduction, whilst the influence of steam is less definite.

Discussion.

Mr. Alfred Hutchinson (Past-President) expressed admiration of the perfection of the apparatus used and the experimental execution of the work, which represented the fifth part of most important investigations. Although, he said, we had made millions of tons of pig iron in blast-furnaces, our ignorance of what occurred in the furnaces had been very profound, and very little work had been done on the subject from the time Sir Isaac Lowthian Bell had written his great book, in 1872, until Professor Bone and his colleagues had commenced their investigations some years ago. He expressed congratulations upon the energy and determination with which the work had been done; results had been obtained in the laboratory, field experiments had been made on the Lincolnshire ores, and then the work had been continued on the North-East Coast, where Professor Bone had obtained facilities to make the necessary connections to a furnace during its construction at Skinningrove. The results of that work had been published, and the paper represented a continuation of it.

Dr. E. Gregory (Parkgate Iron and Steel Company) said it appeared from the paper that both hydrogen and steam in small amounts exerted somewhat similar effects on both carbon deposition and velocity of ore reduction, as might have been anticipated. If steam were added, partial dissociation into hydrogen and oxygen would be expected; on the other hand, if hydrogen were added, one would expect the formation of a certain amount of steam. In the blast-furnace dissociation of steam would be expected to occur in the hottest zone, *i.e.*, just above the tuyeres, since the reaction was endothermic, and he would expect that the dissociation would occur in practice to a greater extent than in the authors' experimental system.

Undoubtedly there was carbon deposition, and the carbon impregnation would appear to account for the disintegration of the lumps of ore, as they descended the blast-furnace shaft. But in the blast-furnace the ore was in contact with coke, some of which might descend to a very low level, as far down as the tuyeres. He discussed the reaction accounting for carbon deposition, and said that, if we were to accept that carbon deposition was responsible for the disintegration of the ore, the influence of coke in that connection could not be disregarded. Therefore, he suggested that experiments conducted at 450 deg. Cent., might be more in keeping with actual blast-furnace practice if mixtures of ore and coke were used instead of ore alone.

Professor Bone said that that was one of the items on the programme.

Dr. Gregory, discussing the effect of moisture in the blast-furnace gas and the fact that the furnace drove most effectively during cold, dry weather, referred to experiments at Parkgate which showed that there was 10 per cent. less coke consumption during a week in March, when the weather was phenomenally cold and dry, than in a corresponding week in December. The moisture content of the burden was about 2 per cent. less in March than in December. Inasmuch as combined water might be retained at levels considerably below the top of a furnace, he asked whether the authors considered that it had any real effect on either carbon deposition or ore reduction velocity.

Dr. Saunders, replying to Dr. Gregory concerning the dissociation of steam at higher temperatures, and the possibility of more than 2 per cent. of hydrogen existing in the blast-furnace gas, said that from the data the authors had obtained so far, especially with regard to the carbon deposition reaction, a limit was approached with additions in the neighbourhood of 2 per cent. The effect of a further quantity of hydrogen was likely to be relatively small, so that he believed the major effect was as shown in the paper.

With regard to carbon deposition, he said that the carbon, being deposited throughout the interstices of the ore, disintegrated it and caused expansion. Chemical examination showed that the ore contained iron or ferrous oxide nuclei, and that increase in the iron or ferrous oxide surface probably accounted for the large increase in the amount of carbon which could be deposited.

Possibly, when using wet blast, too much carbon was deposited for the requirements of the furnace, and the relative inefficiency where wet blast was used, as contrasted with drier blast, was due to a greater deposition of carbon than was really necessary to meet the requirements of the furnace.

Experiments had shown that, as suggested by Dr. Gregory, considerable quantities of moisture could be retained by a partially reduced ore surface, even at 750 deg. Cent., and it was only possible to eliminate it by circulating over it calcium chloride dried nitrogen free from oxides of carbon.

Professor Bone, commenting on Dr. Gregory's remarks, said that the carbon in coke was very different from that in CO, so that it could not be regarded from the pure mass action point of view. The carbon, as deposited from the gases in the first instance, was very much more active than any carbon that was added. He agreed with Dr. Gregory that carbide of iron was in part, and perhaps to a great extent, responsible for the reduction in the rate of ore reduction at about 750 deg. Cent.

Mr. C. E. Richards then presented a paper on "The Atmospheric Corrosion of Galvanised Wire and its Bearing on Specification Testing," of which the official synopsis runs as follows:—

CORROSION OF GALVANISED IRON WIRE.

The question of specification testing is of great importance to the large user of galvanised wire. In Britain the copper sulphate dipping test (Preece test) still enjoys favour.

It is shown that the Preece test is of little value in determining the resistance of a wire to atmospheric corrosion. It discriminates unfairly against some coatings and flatters others. The predominating factor in the life of galvanised wire in a given atmosphere is the thickness of the zinc envelope, and character-

istics such as the purity and ductility of this coating are of minor importance.

The lives to be expected of wires in different types of atmosphere are calculated, and estimates are given of the cash value of adequate galvanising for a typical wire structure. Savings of the order of 25 per cent. are shown for this structure, in which the cost of wire is only about 10 per cent. of the original cost of erection. The economy is due to the saving on labour costs resulting from fewer renewals.

The wide disparity between the rates of failure in industrial and rural areas is demonstrated, and the fact that under certain circumstances even bare iron patches are of little importance is shown.

Laboratory investigations have given interesting results, but have been of little help in suggesting specification tests.

A plea is made for discarding the Preece test on wires in favour of a stripping test. The ductility test as at present specified (B.S.S. 443) is useful and should be retained.

Discussion.

Dr. U. R. Evans (Cambridge University) said that until recently it was usual to argue that, whilst for rigid materials a thick zinc covering might be best, a thin coating was desirable for wire, since bending would be liable to break a thick covering. The author had shown that protection remained to a very large extent even after the thick covering had been broken. He had rightly pointed out that a flexible thick coat would be better than a brittle thick coat, but that a brittle thick coat would be better than a flexible thin coat, at least in the majority of situations.

Commander Rylands, congratulating the author, said that a research such as he had described had been wanted by the wire trade for a very long time. It must be obvious that, other things being equal, the thicker the coating the longer it would last ; and it seemed that in recent years we had rather overstressed ductility. The present-day ductility test in the British Standards Specification was adequate.

Dr. J. C. Hudson said that the author's experience that a thin wire corroded more rapidly than a thick one was confirmed by the results of other workers, including the results in the Corrosion Committee's report.

Mr. L. Kenworthy suggested that more emphasis might be laid on the effect of the diameter of the wire in resisting atmospheric corrosion.

Mr. S. C. Britton (L.M.S. research department, Derby) said he had never seen the Preece test assaulted with such devastating results as in Mr. Richards' work, and he hoped that, so far as specification testing was concerned, the effect would be to deliver a mortal blow to the method.

Mr. Richards, in his reply, said that when the work described in the paper was commenced there had been no idea of attacking any test. He and his colleagues had required a reasonable specification test, and it had so happened that the Preece test did not give the answer required.

The Fifth Report of the Corrosion Committee.

Dr. J. C. Hudson gave a brief indication of the contents of the Fifth Report of the Joint Corrosion Committee of the Iron and Steel Institute and the British Iron and Steel Federation to the Iron and Steel Industrial Research Council, which report is expected to be published shortly, and said it was a very long report. There was an index at the beginning to facilitate reference. The report was divided into six sections, the first of which was introductory. The second described at length field tests on atmospheric corrosion conducted in various parts of the world, and gave authoritative figures for the corrosion of iron and steel under definite conditions. The third section dealt with marine corrosion, inspection of ships, &c. In one case it was observed that some plates on one of His Majesty's ships were seriously pitted, and a panel of the Committee had reproduced the pitting experimentally. The fourth section dealt with laboratory researches and tests on wires and painted specimens, and contained a number of papers contributed from Cambridge University by Dr. Evans and his colleagues.

It could be calculated, said Dr. Hudson, by making various assumptions, that the total area of steel produced in this country in a year in the form of finished product was of the order of 9600 million square feet. If the whole of that steel were painted—and it was not—the cost of painting would be about £40,000,000. The experiments of the Corrosion Committee had demonstrated conclusively that the correct surface preparation of iron and steel prior to painting would increase the life of paint on the surfaces by 50 or 100 per cent. Therefore the researches had a very practical result.

The next section of the report dealt with the work of the Protective Coatings Sub-Committee, which had carried out a large number of tests concerning protection by paint, and hoped to deal with all kinds of coatings, particularly metallic. That section of the report gave details of a modern method of pickling steel, submitted by Dr. Footner, which was believed to represent a marked advance on previous procedure. The scale removal was carried out in the usual sulphuric acid, but the pickled sheet was dipped in phosphoric acid, and as a result of that procedure much better initial paint life was attained. The protection of steel by oxide coatings deposited by solutions was the subject of papers by Dr. Evans, and a paper was contributed from Farnborough on the protection of steel by coatings other than paint.

The final section contained papers on various matters connected with corrosion. One of them dealt with sulphate-reducing bacteria, because in the corrosion of cast iron, and possibly of steel also, when embedded in soil, the corrosion was accompanied by, or one might almost say was occasioned by, the presence of bacteria which acted as hydrogen acceptors. There were also references to the corrosion of steel sleepers, and it could be regarded as proven that a copper-steel sleeper would resist corrosion longer than a sleeper of ordinary steel. It was only fair to say, however, that in many cases ordinary corrosion would not be the determining factor in the life of a sleeper plate.

Finally, he welcomed the cordial relations between the bodies studying corrosion in the various countries, and said the report made reference to the state of corrosion research in the United States, Belgium, France, Germany, Holland, Poland, Sweden, and Switzerland.

Empire Exhibition, Glasgow.

No. V.

(Continued from page 592, May 27th.)

OUR description of the engineering exhibits at the Empire Exhibition, Bellahouston Park, Glasgow, is continued in the following article.

Butters Brothers and Co.

Amongst the exhibits of crane machinery on the stand taken by Butters Brothers and Co., of 3–8, Duncannon-street, London, W.C.2, are a complete gear unit for a 3-ton electric derrick crane shown under power, a 2-ton electric hoisting winch, and an electric overhead travelling crane crab of 3 tons capacity.

In the accompanying engravings, Figs. 33 and 35, are reproduced a drawing of the overhead hoisting crab and a view with a portion of the gear casing removed. In this latest design, all the gears are enclosed within an oil bath gear case, provided with glass inspection covers. Moreover, the design is an example of the application of ball and roller bearings and electric welding to the construction of electric overhead travelling cranes. Messrs. Butters Brothers state that until recently crane users have been reluctant to take advantage of these methods and were content with the older type of crane with exposed gearing and bushed bearings.

In the crab illustrated, the triple reduction hoist gear is driven by a motor developing 10 H.P. on a half-hour rating, running at a speed of 705 r.p.m. The gearing runs in oil and is contained in a totally enclosed cast iron gear-box, made in two halves bolted together with fitted bolts. Forged steel pinions and cast steel gear wheels with machine-cut teeth are employed. Double helical gearing is used on the first reduction train ; and as this type of gear locates the motor extension shaft, rigid bearings are used which have freedom of movement in a sideways direction. Since the first and second intermediate shafts are short and accurate alignment between the bearing seatings is readily obtained, these shafts also are mounted in rigid bearings. On each of these shafts one bearing has its outer race located, while the corresponding race on the other bearing is free to move sideways. To ensure correct alignment of the barrel shaft, a self-aligning bearing is introduced in the cast iron bracket on the far side of the barrel, the shaft being located by two bearings within the gear-box. All ball and roller bearings are of Hoffmann manufacture.

The snatch-block is suspended on four parts of flexible plough steel wire rope accommodated in one layer on the barrel, which is machine grooved right and left hand, so as to obtain a vertical lift for the hook. Control of the load is effected automatically by an electro-magnetic brake operating on the rim of a flexible coupling connecting the armature and motor extension shafts. The brake is released as soon as current is applied to the motor, and it is applied whenever the supply is switched off or if the current should fail.

In order to prevent over-hoisting a self-resetting limit switch operated by the snatch-block through a weighted lever attached to the crab is fitted. Should the load be raised until the switch comes into effect, it is only necessary to reverse the direction of the controller handle and allow the snatch-block to be lowered clear of the weighted lever, when the switch will reset itself to its normal position.

Cross traversing is obtained by driving one crab axle by a 2 H.P. motor running at 690 r.p.m. through two reductions of spur gearing, enclosed in a cast iron gear-box and running in oil. The shafts and axles are supported in self-aligning ball or roller bearings in a similar manner to that described above for the hoist gear.

In order to give a light and rigid frame the crab is made from steel plate and sections welded together. All the parts are accessible and the assembly is compact. Convenient inspection covers and oil level indicators are provided on each gear-box.

On the stand at the Exhibition it is only possible to show the crab, but the longitudinal travelling gear for the complete crane, of course, has been

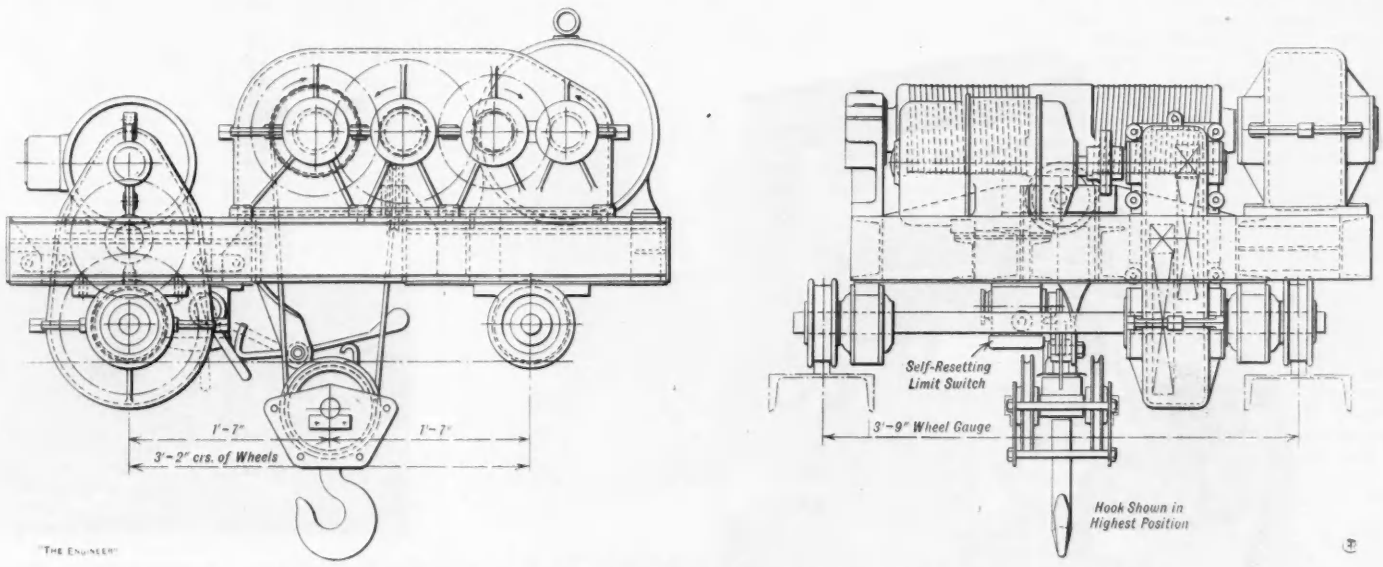


FIG. 33—ARRANGEMENT OF 3-TON ELECTRIC OVERHEAD TRAVELLING CRANE CRAB—BUTTERS

constructed on similar lines. For this movement, the motor is mounted near the centre of the span on one girder, driving a cross shaft through a single reduction double-helical gear enclosed in a cast iron gear-box. Supported on self-aligning ball bearings, this cross shaft transmits the motion through another gear reduction to one wheel on each end travelling carriage. The travelling wheels are mounted on fixed steel axles fitted with roller bearings. A brake wheel is keyed on the cross shaft and the travelling of the crane is controlled by a foot-operated lever in the control cage, the lever being connected to the brake shoes by a simple linkage.

Large gusset plates with turned and fitted bolts connect the box-section end carriages to the lattice girders. All the other girder components are riveted together; it is stated that it has not been found economical to fabricate welded lattice girders. On the travelling gear side a platform is provided along the whole length of the girders and the control cage is normally situated near one end of the girders, suspended therefrom, although the position can be readily altered to suit local conditions. The motors are controlled by tramway controllers connected to unbreakable grid resistances. To protect the motors and controllers from overloads, a suitable protective panel is mounted at the back of the control cage.

The main exhibit on the stand is illustrated in the accompanying engraving, Fig. 36, which shows a complete gear unit for a 3-ton power derrick crane. This crane is stated to embody several new features and yet to be standardised to such an extent that maintenance and spare part charges are small. One of the chief features of the crane is that the operator has a clear view of all operations, for the control platform is placed well above the jib bottom pin, and the operator stands on the left-hand side of the main gearing. Special attention has been given to the disposition of the gearing, which forms a compact but easily accessible unit. The controls have been simplified as much as possible and the leverages have been proportioned in such a way that the controls can be operated with the minimum of exertion.

The drive for the hoisting barrel is taken through spur gearing from a 15 H.P. slip-ring induction motor, half-hour rated, running at 700 r.p.m. Mounted on an extension shaft which is connected to the armature spindle by a flexible coupling is the motor pinion for transmitting the power to the driving shaft. The extension shaft is mounted on a ball-bearing bracket and is provided with a brake wheel. Two speeds of hoisting are available. The fast speed is obtained by single reduction spur gear from the driving shaft, with a capacity of lifting 1¼ tons at 130ft. per minute. The slow speed is through double reduction gearing, giving a capacity of 3 tons at 50ft. per minute. The speed change is effected by a sliding pinion mounted on the driving shaft operated by a hand lever on the control platform. Loads can be gravity lowered by moving the sliding pinion to a neutral position and thus allowing the hoist barrel to run freely, the load being controlled by a foot brake.

The derrick gear is driven through a clutch from the hoist barrel shaft by a single reduction spur gear train, the ratio of which is such as to give the desired load path to minimise the power required in lifting the jib. A feature which is claimed to be unique for the Butters derrick crane is that the derricking motion can be operated from the hoist gear fast speed, thus reducing the time cycle of operations. Sustaining the jib is a forged steel pawl which engages with ratchet teeth cast integrally with the derrick barrel. To alter the radius of action of the crane, the clutch is engaged and the jib pawl lifted clear of the ratchet. Another feature of the design is the interlocking device between the derrick clutch and pawl levers. This device, which has been approved by the Home Office, makes it impossible to lift out the pawl until the clutch is engaged, thus eliminating the possibility of an accident arising from this cause.

Foot-operated, the main brake consists of a simple system of levers connected to a spring steel band lined with "Ferodo" material. An adjusting screw is provided to compensate for the wear of the lining, and the foot tramp lever has teeth cut in it to hold the brake and load in any required position. A hand brake is fitted on the motor spindle, which is normally used when the driver wishes to change gear quickly, but which can be used also in an emergency to hold the load.

The crane is slewed by an independent motor, developing 5 H.P. at 695 r.p.m. through a train of spur gearing revolving round a large-diameter cast steel rack with machine-cut teeth. A slip friction device is interposed between the motor and the rack in order to protect the gear from overload should the jib strike any obstacle. The gearing is fitted with a mechanically operated band brake, lined with "Ferodo" material, applied by a hand lever. The brake has a screw for adjustment and also a trigger gear so that the crane can be held in any position.

Constructed of rolled steel sections riveted together, the mast is designed for maximum rigidity combined with low weight. To facilitate transport and erection, a joint is made in the mast above the gearing. To reduce noise, the motor pinions for both motors are made of compressed paper with steel side plates;

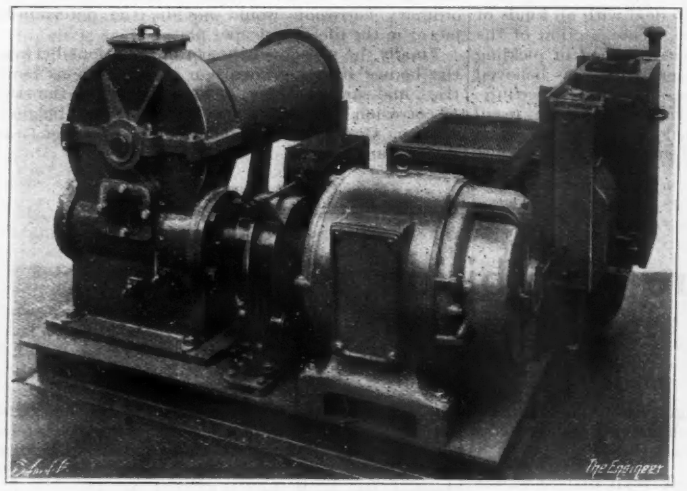


FIG. 34—ELECTRIC HOISTING WINCH—BUTTERS

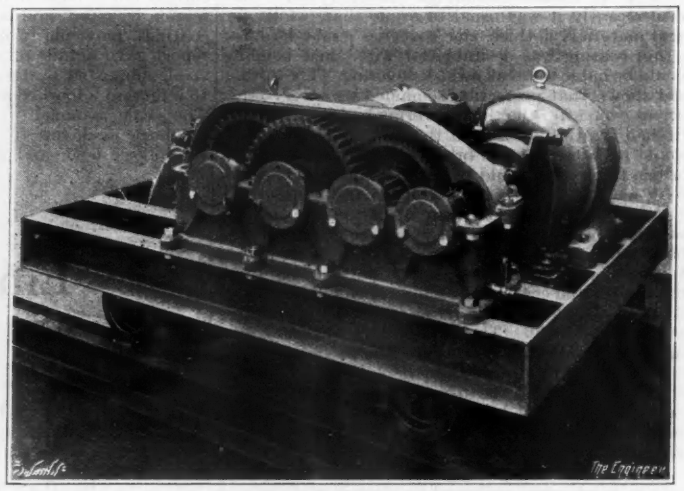


FIG. 35—CRAB FOR OVERHEAD CRANE—BUTTERS

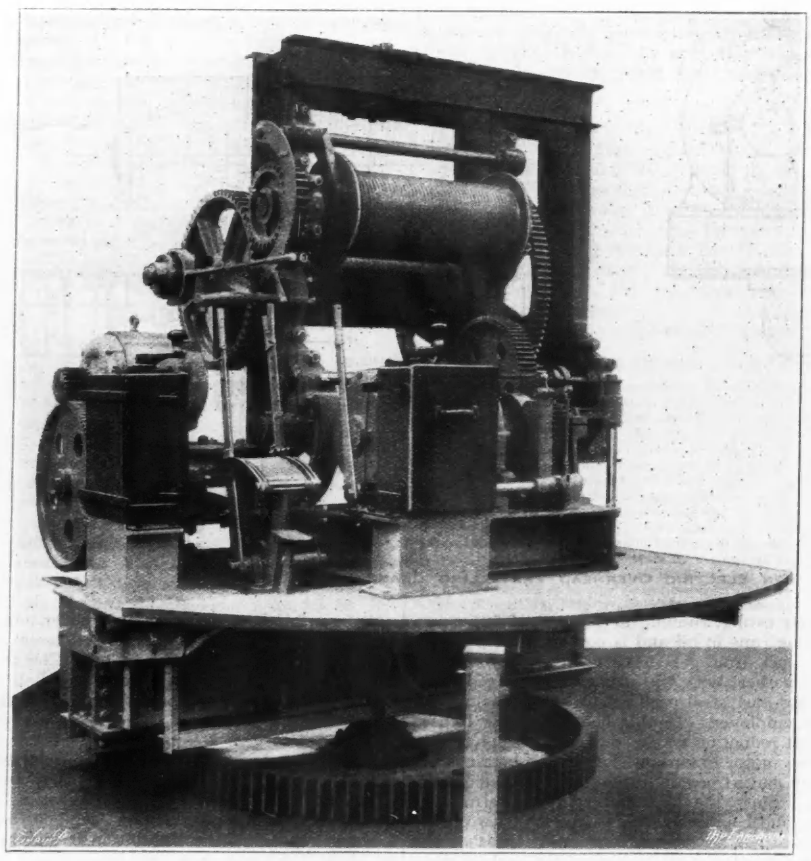


FIG. 36—GEAR UNIT FOR 3-TON POWER DERRICK CRANE—BUTTERS

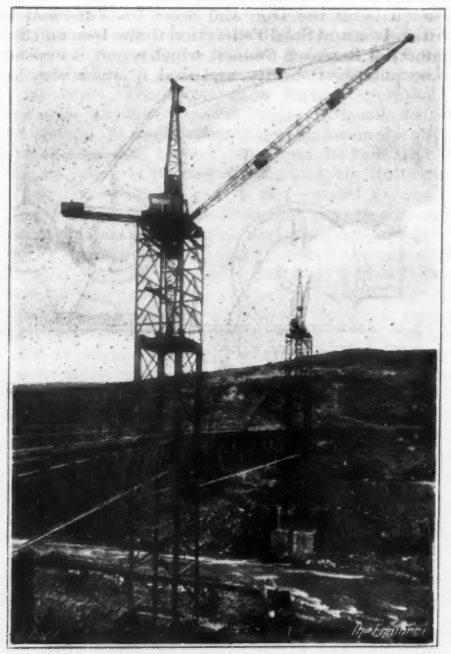


FIG. 37—MONOTOWER CRANES AT LOCH LAGGAN—BUTTERS

otherwise all the gearing is machine-cut in steel. A jib-operated radius indicator is fitted, and, of course, any approved safe load indicator with audible or visible warning devices can also be fitted. All power derrick cranes built by the firm are mounted on steel soleplates, with a single pin connection for the sleepers, and the slewing racks are securely mounted on the soleplates.

Variations of the design include a three-motor crane, in which a separate motor is used for the derricking motion, through worm gearing, also single-motor cranes. The last-named type is similar to the two-motor crane described above, with the exception of the slewing gear, which is driven through a single-reduction spur gear from the driving shaft through friction cones. This design is readily converted to suit any type of prime mover, such as a steam or oil engine, when an electricity supply is not available. Cranes for grabbing work can be fitted with a separate gear for operating the two-line type of grab or ring discharge and self-dumping grabs can be readily mounted.

Derrick cranes manufactured by the firm are fitted with jibs up to 150ft. in length, while designs are said to be available for cranes of a lifting capacity of up to 100 tons.

Another exhibit on the stand is the winch illustrated in Fig. 34. This winch has a capacity of 2 tons at 100ft. per minute, and is driven through worm gearing by a 20 H.P. electric motor running at 705 r.p.m. The motor is coupled to the worm shaft by means of a combined flexible brake wheel and coupling. Cut from a solid steel blank, the worm is mounted on "Timken" tapered roller bearings, while the worm wheel, which has a cast iron centre to which is fitted a phosphor-bronze rim, has machine-cut teeth. The assembly runs in an oil bath, and is claimed to have a high efficiency. Keyed to the same shaft is the barrel which is grooved to suit the wire rope, according to B.S.I. specification.

An automatic electro-magnetic brake, capable of holding the full load, is fitted on the motor spindle. This brake is automatically applied if the current is cut off or if it fails. The frame is built up from plates and sections welded together, giving a compact and robust arrangement, while the E.M.B. control gear is placed in a convenient position for the operator. The electric motor fitted to this winch is of Crompton-Parkinson manufacture, as are all the motors fitted to the exhibits on this stand.

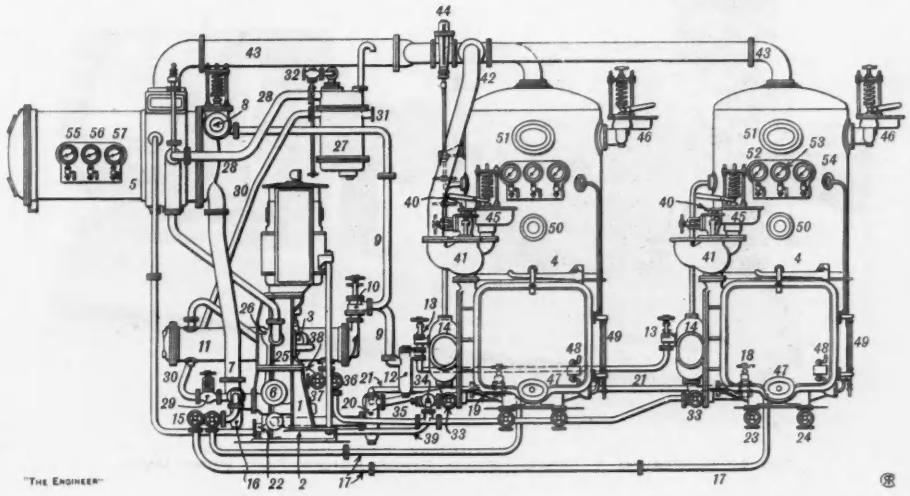
In addition to the three full-size exhibits described above, Messrs. Butters Brothers are showing various models, including a hand power derrick crane, an overhead electric three-motor crane, a wharf electric four-motor crane, and a "Monotower" electric crane. Messrs. Butters Brothers claim to be the only manufacturers in this country of the last-named type of crane, which is said to have considerable advantages. In Fig. 37 are illustrated two such "Monotower" 7-ton electric cranes, with an interconnecting bridge consisting of a 200ft. centre span and spans of 100ft. at each end, at Loch Laggan. The towers are 145ft. high and the jibs 100ft. long. The Lochaber water power scheme, on which these cranes were used, was fully described in issues of THE ENGINEER for May, 1936, and June 5th, 1936. After use on this scheme, the towers of these two cranes were shortened to a height of 50ft. and they are now being used on travelling bogies on the Kut barrage scheme for the Iraq Government. Amongst the advantages claimed for this form of construction is the fact that it can revolve in a complete circle, and therefore the area served is the maximum possible for a jib crane, since the full load can be handled with the jib practically horizontal. Furthermore, on building contracts the crane can remain erected until the job is finished, and the ground area occupied by the tower is comparatively small.

G. AND J. WEIR, LTD.

Power plant auxiliary machinery, representing many of the products of G. and J. Weir, Ltd., of Cathcart, Glasgow, S.4, for land and marine installations, is on view on the firm's stands in the Palace of Engineering. Included in these exhibits is a complete evaporating and distilling plant, illustrated in the accompanying line engraving, Fig. 38. This plant, shown by permission of the Admiralty, is for a modern warship. It comprises two vertical evaporators, a distilling condenser, an air ejector, and a combined circulating water, fresh water, and brine pump. The plant can be operated for single or double effect, as required.

Working single effect, one evaporator can be opened for cleaning while the other is under steam. Although complete figures of performance, steam pressures, and so forth cannot be given, the output can be stated as approximately 100 tons of fresh water per twenty-four hours for each evaporator, working single effect, or approximately 130 tons of fresh water from the pair of evaporators working double effect. In the first case, the coils are supplied with steam at 25 lb. per square inch, while in compound effect the vapour from the first effect evaporator is led to the coils of the second evaporator, the coil drain from the second evaporator being connected to the distilling condenser.

The bases or water spaces for the shells of the evaporators are made from Admiralty gun-metal and the vapour spaces are of sheet brass, each of these spaces being tinned internally. Made from solid-drawn copper tubes, the heating coils have their ends expanded into stainless steel coupling tail pieces. Each tube is arranged so that it can be withdrawn separately, and, with the large door for withdrawing coils removed, the tubes can be steam tested, after being replaced in the steam headers. Float-operated automatic feed controllers, provided with a hand wheel adjustment for raising



1	Circulating pump.	21	Brine pump suction.	*38	Coil drain from heater to condenser, &c.
2	Brine pump.	22	Brine pump discharge.	*39	Coil drain to distilling condenser.
3	Fresh water pump.	23	Blow-down to sea.	40	H.P. steam inlet valve.
4	Evaporator.	24	Blow-down to bilge.	41	L.P. steam inlet valve.
5	Distilling condenser.	25	Fresh water suction.	*42	Vapour from No. 1 evaporator to No. 2 evaporator (double-effect).
6	Circulating pump suction.	26	Fresh water discharge.	43	Vapour to distiller.
7	Circulating pump discharge to distilling condenser.	*27	Air ejector.	44	Sluice valve, vapour to distiller.
8	Circulating discharge overboard, through spring-loaded valve.	*28	Air suction from distilling condenser.	45	Coil safety valve.
9	Feed to evaporator.	*29	Air ejector circulating water valve.	46	Shell safety valve.
*10	Heater by-pass valve.	*30	Circulating water connection to air ejector.	47	Cleaning door.
*11	Feed heater.	*31	Circulating water discharge to sea.	48	Salinometer cock.
12	Weed trap.	*32	Air ejector steam stop valve.	49	Water level gauge.
13	Feed check valve.	33	Coil drain valve.	50	Inspection window.
14	Evaporator feed regulator.	*34	Coil drain two-way cock to heater by-pass valve or bilge.	51	Inspection door.
15	Cooling water valve.	*35	Coil drain to heater.	52	Gauge—Steam to coils.
16	Weed trap (cooling water).	*36	Heater by-pass valve.	53	,, Coil drain.
17	Cooling water to brine suction.	*37	Coil drain connection to condenser, &c.	54	,, Evaporator shell.
18	Brine valve (water sealed).			55	,, Distiller shell.
*19	Brine ejector.			56	,, Evaporator feed.
20	Weed trap.			57	,, Evaporator feed outlet.

NOTE.—Items marked thus * apply to double-effect plants only.

FIG. 38—NAVAL EVAPORATING AND DISTILLING PLANT—WEIR

or lowering the water level, regulate the level of the water in the evaporators.

Disposed horizontally, the distilling condenser is capable of condensing the whole of the output of the evaporators, working either single or double effect. The condenser is constructed of rolled naval brass with gun-metal end flanges tinned internally; brass baffle and diaphragm plates are fitted, and the tubes, secured in the tube plates by screwed ferrules, are made from internally tinned solid-drawn Admiralty brass. The distilling condenser

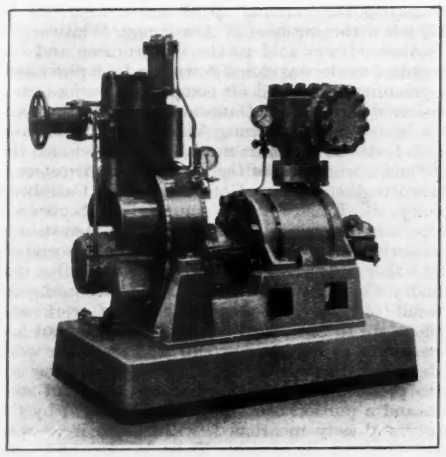


FIG. 39—TURBO-FEED PUMP—WEIR

is evacuated by means of a single-stage steam jet air ejector fitted with an after cooler through which sea water circulates. The condenser circulating water is taken from the discharge side of the distiller circulating pump and it forms the feed for the evaporators.

Fitted on the evaporator feed pipe line are the feed heater and the coil drain cooler. This arrangement serves to heat the feed water and to extract the heat from the drains from the evaporator coils of both evaporators when working single effect, or of the first evaporator when working double effect.

A combined circulating water, fresh water, and brine pump of the firm's "Upright" type is fitted to the plant. This pump has a vertical spindle, driven by a direct-coupled steam turbine, and really comprises three pumps mounted on a common shaft. In an upper separate casing is arranged the fresh water pump, while in the lower casing are arranged the impellers of the sea water circulating and brine extraction pumps, the last-named being mounted at the lowest point in the casing. The casings are of gun-metal and are fitted with renewable impeller clearance rings. They are split on the vertical axis and the pump branches are carried on the rear casing so that the rotating parts can be examined or removed without the necessity for breaking any pipe joints. The impellers of all three units are made of phosphor-bronze and the common spindle is of hard rolled phosphor-bronze. The pump is stiffened by two heavy steel columns connecting the base with the turbine framing.

Of the firm's impulse pattern, the turbine has one pressure and three velocity stages, with the blading and shrouding constructed of stainless steel. As the distilled water is handled by the upper separate pump, there is no possibility of sea water contamination. The two lower pumps are so arranged that any tendency towards brine leakage through the pump bushes will be in the direction of the brine pump; furthermore, by reason of the position of the brine pump—at the lowest level—the static head above the brine pump impeller is a maximum. In addition, brine ejectors are fitted in the diluting sea water connections so as to assist the operation of the brine pump when extracting brine at a high temperature.

To measure the amount of fresh water discharged to the tanks a Kent water meter is fitted, and the purity of the water is recorded on a paper roll by a Crockatt salinometer. The last-named instrument operates by measuring the electrical conductivity of the water; the degree of conductivity, of course, depends on the amount of salts present in the water. If the salt content rises above a certain limit, a red light glows and remains lighted until a proper figure is regained.

Feed water for the evaporators is supplied from the distiller circulating pump discharge through a spring-loaded valve and the automatic regulators, mentioned above, control the level of the water in the evaporator shells. When working single effect, steam is supplied to the heater coils and the drains are led to the drain cooler. The evaporator vapour is discharged to the distiller, wherein it is condensed, and the fresh water is then withdrawn by the pump and discharged through the meter to the tanks. When working compound effect, as already mentioned, the vapour from the first evaporator forms the heating steam for the second evaporator, and the coil drainage from the last named, being distilled water, is led to the distiller.

Another interesting exhibit is one of the main turbo-feed pumps for the new Cunard liner "552," which is being shown by courtesy of John Brown and Co., Ltd. This pump (Fig. 39) has two stages

and is mounted together with the turbine on a combination bed-plate. The pump body is formed of cast steel ring sections supported at the centre line on suitable brackets in such a way that the effects of expansion on alignment by reason of the high temperature of the feed are minimised. The pump and

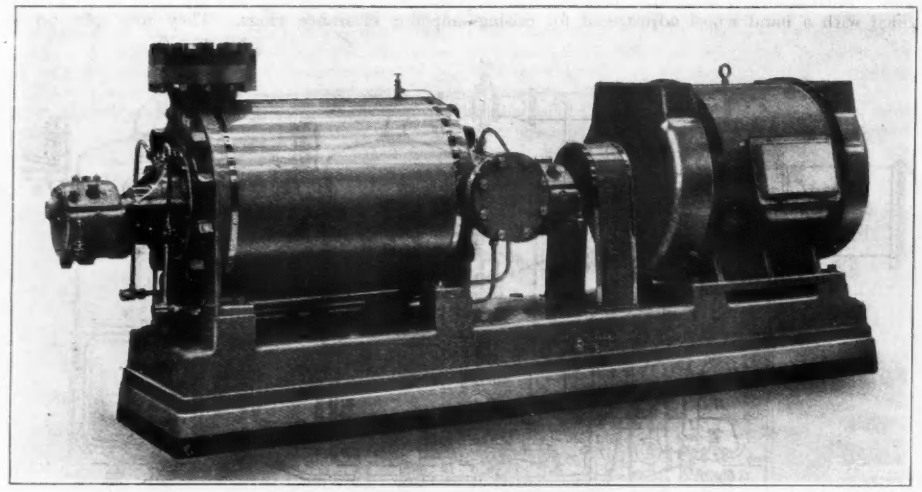


FIG. 40—ELECTRICALLY-DRIVEN MULTI-STAGE BOILER FEED PUMP—WEIR

covers are of cast steel, the whole being heavily bolted together by through tie bolts. The shaft is lined with hard Monel metal sleeves where it passes through the pump glands. Monel metal is also used for the impellers and diffusers. Self-oiling water-cooled, ring-lubricated bearings are used; the centre bearing is provided with thrust collars to take up the axial movement of the shaft on starting and stopping. Under running conditions the thrust is completely balanced by a hydraulic balancing device arranged within the pump.

The impulse turbine has one pressure and three velocity stages, and is provided with the firm's automatic pressure governor which is claimed to enable the discharge pressure to be maintained at all loads. A centrifugal emergency governor is also fitted, operating on the steam throttle valve. In

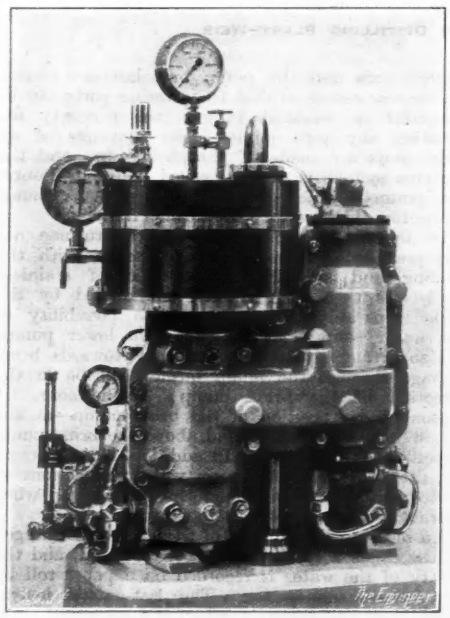


FIG. 41—GEARED TURBINE—WEIR

order to prevent overheating at light loads, a dashpot cushioned non-return valve embodying an automatic by-pass is fitted to the pump discharge.

Illustrated in the engraving herewith, Fig. 40, is another of the firm's exhibits—a high-pressure electrically driven boiler feed pump for power station plant, known as the Weir "Electrofeeder." The pump has a capacity of 500,000 lb. per hour, and is designed for a discharge pressure of 950 lb. per square inch, with seven stages. It is built up from cast iron ring sections, with the end covers connected together by tie bolts. The impellers and diffuser rings are of gun-metal, and the shaft, of Siemens Martin steel, is protected at the stuffing-boxes by hard Monel metal sleeves. The bearings are white-metal-lined, lubricated by oil rings, and a hydraulic balancing arrangement is incorporated in the discharge side of the pump. The speed of the motor is 2950 r.p.m.

To give inherently stable operation, the pressure capacity characteristic of the pump is stated to be carefully designed so that the pump starts to discharge against the full pressure of the mains. In this way it is claimed that parallel operation with other pumps of similar character can be effected without surging, the load being shared with electrically driven or turbine-driven pumps. Pumps of this type for use with high feed temperatures are also manufactured by the firm. In this case the pump body consists of a cast steel barrel suitably lined to prevent corrosion, arranged for suspension from the centre line, to minimise expansion effects, as described above in connection with the turbo-feed pump.

A vertical-spindle geared turbine suitable for pump or other auxiliary drives is illustrated in the accompanying engraving, Fig. 41. It is particularly suitable for such duties as driving an extraction, fire, or bilge pump, or oil pressure pump drives, particularly for Admiralty work.

One pressure and two velocity stages are arranged within the casing, forming an impulse turbine. Cast steel is the material used for the casing and nozzle boxes and stainless steel for the blading and shrouding. The shaft is of chrome-nickel steel running in white-metal-lined journal bearings.

Single-reduction helical gears reduce the speed from about 6500 r.p.m. to 1150 r.p.m. The pinion of the reduction gear is forged in one piece with the turbine shaft. Operating on a balanced throttle valve, a governor driven from the slow-speed shaft by means of a second set of helical gears is fitted for speed-control purposes. While the turbine is in operation the speed can be varied over a considerable range by means of a hand-operated device. An emergency governor is fitted which closes the steam stop valve by means of a trip gear when the speed of the turbine reaches a predetermined limit. Thus, should the supply to the pump served by the turbine fail, or the load be removed from any other cause, it is stated that there is no possibility of the turbine speed reaching a dangerous value.

Built into the turbine framing is an oil cooler employing U tubes suitable for water circulation. Lubrication is effected by distributing oil to the bearings and to a reduction gear spray nozzle by means of a small gear pump driven from the lower end of the speed governor shaft.

The designed power of the turbine shown is from 20 to 30 H.P., but a range of sizes is available to suit a variety of drives. Direct drive turbines are also built by the firm for similar duties, one of this type being shown on the combined circulating, fresh water, and brine pump on the evaporating and distilling plant referred to above.

(To be continued.)

New Industries at Jarrow.

LAST Friday, May 27th, there were officially opened at Jarrow two new works, which will bring employment to a district which has until recently been more distressed than any other. The two new associated companies, Jarrow Metal Industries, Ltd., and Jarrow Tube Works, Ltd., have come into being largely as the result of the activities and determination of Sir John Jarvis, who became interested in the town when as High Sheriff of Surrey he inaugurated the Surrey Fund, which has expended £40,000 in helping Jarrow. The Fund has been expended not only on providing materials for redecorating clubs and buildings, on the purchase of boats for sea fishing and similar useful but small purposes, but has also been used for purchasing and reconditioning factories, in connection with the deepening of the dock at Palmer's Yard for the shipbuilding industry, and for other similar activities for encouraging the building up of new industries. In 1937, when the business of Armstrong, Whitworth's at Scotswood was sold to the Government and the locomotive works was closed down, Sir John purchased the pneumatic tool and air compressor business and transferred the work to Gateshead, forming the company known as Armstrong Whitworth (Pneumatic Tools), Ltd. At the same time, he also purchased the share and loan capital of the whole of the Armstrong, Whitworth Company at Gateshead. The Gateshead foundry, which had formerly supplied the Scotswood works, was reconstituted as Sir W. G. Armstrong-Whitworth (Ironfounders), Ltd., and in association with it there was started up the Patent Axle Box and Foundry Company (1937), Ltd., in Gateshead. As a result of the consequent transfer of work and employment to Gateshead it was possible without loss of employment in that town to transfer other work to Jarrow. Jarrow Metal Industries, Ltd., was set up to produce tube billets, steel castings, and steel rolls, and a portion of its output is absorbed by the concerns already mentioned, with which it is associated, and by the Jarrow Tube Works, Ltd. Sir John Jarvis is chairman of all the companies.

In the following paragraphs we print in abstract the speech which Sir John gave in connection with the opening ceremonies, which extended over two days and included the inspection of the work carried out by the Surrey Fund.

My coming to Jarrow in 1934 was in the nature of adventure. I was then High Sheriff of Surrey and I was looking for a national task to justify the holding of this high office. It was suggested to me that no greater service was at hand than to help one of the distressed areas. I visited the Ministry of Labour and inquired which was the worst area of all, and was told Tyneside, where Jarrow, with nearly 80 per cent. of its workpeople unemployed, was the blackest spot.

First of all, I asked the people of Surrey to subscribe to a fund to help, and within a few weeks they placed nearly £40,000 at my disposal. Then I came North, to a district entirely unknown to me. I quickly appreciated the magnitude of the task. I realised that whilst money could provide some immediate palliatives, something far more was needed if the grim problem of mass unemployment was to be solved.

My first task was admittedly palliative; it was to bring the people of Jarrow a new hope and give them something to do. To convince them they were not forgotten—that the time for talking about them had passed and the time for action had come. I am not going to weary you with a recital of all that was done with the money of the Surrey Fund, not by charity—the men of the North are still proud—but by co-operation.

But from the very start I realised that our main aim must be to assist the unemployed man to get fit, and to provide him with a permanent job, and that our scheme would be judged, in the ultimate, by our success or failure in finding new and suitable industries. My plan was to find industries new to Jarrow and of the highest standard of efficiency, to fight unreasonable opposition arising from selfish or jealous interests, and to procure finance on the most economical terms. After nearly four years of struggling I believe we have won through.

The type of industry to start in Jarrow was of great importance. It should provide work of a permanent character suitable for the home and export market. The men had been used to the heavy work of commerce—steel making and shipbuilding. As shipbuilding—wisely or unwisely—had been banned at Jarrow, we had to look elsewhere. It seemed to me that a scheme which started with shipbreaking—using the scrap in a new steel works, which, in turn, would produce the steel for a variety of finishing processes—was the correct round. To this scheme I have adhered as closely as possible. The Surrey Fund bought a Greek steamer in 1936 to test the value of Jarrow labour. They sold it to a shipbreaking company for £300 less than it cost to meet the risk of untrained labour being uneconomic. Jarrow men justified themselves to such an extent that the shipbreakers, upon the conclusion of their work, procured subscriptions for the Surrey Fund to make good the whole of the loss. This example proves—which has been confirmed since—that there is nothing the matter with the majority of the Jarrow workmen. They are keen, anxious to learn, and prefer work to idleness, of which they are heartily sick. Their hands may have temporarily lost their nimbleness, their muscles may need stimulation, but in a few weeks most of them can tackle their jobs well and I am proud of them. After the Greek steamer I bought the "Olympic" for just on £100,000, and the Surrey Fund joined with the Tyne Improvement Commission in providing over £2000 to deepen

the dock in Palmer's Yard, so that she might be broken up there. Two or three other vessels were dealt with and proved invaluable to steel makers at a time when scrap was very badly needed.

We have not been able to bring another ship alongside recently, because the proposed new steel works company had not decided how much of Palmer's Yard they were likely to need. This has now been settled, and the Commissioner for Special Areas has just offered me 17 acres of the old shipyard, including the dry dock, and full access to the river on a short notice agreement, and I hope that this new industry will continue its usefulness for a long time to come.

The collapse in 1936 of the main steel works proposal is now history, and I do not propose to dwell upon it. This was the one industry in which I never had any measure of control. It was run by an outside syndicate, and although they invited my help, which I gladly gave, I had no voice in their programme or their policy. There is to-day a new steel works company projected, on a very much smaller scale than the original scheme. I have nothing to do with it myself, but I understand it is not intended, at present, to be more than a section of a steel works. Under the most favourable circumstances, it cannot be in operation until 1941, and even then it is most unlikely to employ as many men as are likely to be working in our Jarrow Industries by then.

Some of you have already seen Messrs. Greaves and Thomas's Furniture Works, a most praiseworthy effort, and of the others I will first mention Jarrow Metal Industries, where you will see a steel melting plant of Italian design in operation. It is the first of its kind in the country and we believe it has no equal in Europe. It will make all the steel we need for our new industries, both in Jarrow and Gateshead, and will absorb all the scrap we can make in our ship-breaking industry.

You will also see the manufacture of refined iron, and a 35-ton pulverised fuel air furnace of American design capable of making other grades of steel. To-morrow, at Gateshead, you will notice a battery of rotary melting furnaces of French design, also the first operated in England using pulverised fuel. With this equipment we are entirely independent of outside supplies of iron and steel. We are also manufacturers of heavy steel castings, and we have concluded a very favourable contract with a Pittsburgh company for licence to make high hardness rolls of a very superior quality.

The other finishing processes you will see at the Jarrow Tube Works. You may think it is very daring to compete with one of the most highly organised industries in the land. We believe that we have machinery and methods based upon modern Continental technique which will supplement rather than compete with the output of existing tube manufacturers in the country. These works will, as I have said, absorb a large proportion of our own steel. We shall specialise in the manufacture of high-grade cold-drawn precision tubes, not only in steel, but in other metals and alloys, for which there is a great demand. Mr. Ben Price, a veteran tube maker, with world-wide experience, is our consultant.

These works are capable of employing many times the number of men you will see working to-day, and from the orders which are coming from all quarters we shall extend our pay roll as fast as the men can be trained.

I have spoken of machines from Germany, Italy, France, and America, and the thought may have come to you that it was strange that we were not supporting entirely British industries. We have only gone abroad for our machinery where we could not find its equal in England. I have flown many thousands of miles in Europe in the last few years trying to find industries different and more efficient in their way to anything at home. I am certain the policy of introducing the very latest type of plant is a sound one, no matter where it comes from.

On this subject I should like to make two points. The first is that every £1 we have spent abroad has resulted in £7 being spent in England. Not 15 per cent. of our capital has been spent overseas, and the balance has given employment to thousands of men in various parts of Great Britain, many of them in other distressed areas. The second is that against the money spent abroad we are making goods which will be exported not only to many Continental countries, but to the far ends of the earth. At Jarrow we have orders on hand for Denmark, Sweden, and Switzerland, and further afield, Canada, Australia, and India. Not small orders, but substantial contracts which will bring considerable employment to the town. At Gateshead, to-morrow, you can see work being carried out on expensive axle-boxes of very high quality for China. This work was stopped a few weeks ago, but it is now proceeding again and payment has been guaranteed. I suggest that these are justifications for our foreign purchases. I believe that trade should be more international, and that we should be buying abroad things which we cannot produce at home, and selling our products in foreign markets which may thus be opened to us. I am convinced that this world policy of economical nationalism, which denies to each country the good things produced in all the other countries, is all wrong, and I am quite unrepentant of our excellent purchases abroad.

It may be of interest to you to know the present official unemployment figures for Jarrow, compared with those when I first came North four years ago. The Jarrow figures, excluding Hebburn, showed that over 6000 men were unemployed in 1934. To-day there are only 2322 men without work, and the percentage of unemployed people has fallen from nearing the 80's to a present figure of approximately 30 per cent. I am not claiming anything like all, or, indeed, any of the credit for this much more satisfactory state of affairs, although I hope that the men that we have put to work in and out of Jarrow and the publicity that has been given to the needs of the North has contributed to a material extent. In my opinion, it is not good publicity to pretend that Jarrow is down and out. The position is improving every day, and it is far wiser to let the truth be known to encourage others to start industries in a town which will soon be prospering again. Industrialists shun distressed areas. They think there must be something wrong with them, and the sooner it is known that Jarrow is out of the distressed area category, the better it will be for the town. The unemployment problem of Jarrow is now assuming measurable proportions. Of the 2322 unemployed men, it is probably true to say that one-third of them are unemployable in heavy work, through age, sickness, infirmity, or other causes. That would leave, roughly, only 1500 men to be put back into industry, to leave no able-bodied unemployed man in the town. Indeed, if we could find work for only a thousand, the remaining 500 would be absorbed in supplying the needs of the others.

If the steel works plan matures, as I hope it will, and other industries are started which I have in view, we shall very soon be calling back the men who, living in Jarrow, have had to find employment elsewhere. I have never been wedded to transference, and the sooner the older Jarrow men are back in Jarrow, the better I shall be pleased.

When I first came North I heard again and again that it was the Government's job to find work for Jarrow, and not an individual. I am not sure that that is true. Governments and Government Departments are not constituted to start industries and run them economically and profitably. An industrialist can take a risk which a Government cannot. What a Government can do is to frame a long-term policy to help industry and to create an atmosphere in which industrialists can work out that policy in detail to a successful conclusion. Big fellows like Lord Portal are doing this in South Wales, in the same way as I have tried to do it in Jarrow. I believe there are many capable men with great commercial knowledge and ability who feel they owe a duty to their day and generation, who, if they were invited and encouraged, would gladly come forward and give their best endeavours to help back on the road to prosperity those distressed areas in which our men have been unemployed all too long.

Institution of Mechanical Engineers

CARDIFF SUMMER MEETING.

No. I.

UNDER the presidency of Mr. David E. Roberts, the Summer Meeting of the Institution of Mechanical Engineers opened at Cardiff on Monday of this week, May 30th. In the afternoon of that day those taking part in the meeting were welcomed to the city by the Lord Mayor and the members of the Cardiff Reception Committee, and during the evening they were entertained to a dinner and dance by the Monmouthshire and South Wales Coal Owners' Association. On Tuesday morning, while the ladies visited certain points of local interest, the members assembled in the meeting hall of the South Wales Institute of Engineers to hear and discuss a paper by Mr. W. F. Cartwright, entitled "The Design and Operation of a Modern Blooming Mill." We begin a reprint of this paper elsewhere in this issue. During the afternoon visits were paid to Guest Keen Baldwins' works at Cardiff, and to those of the Whitehead Iron and Steel Company at Newport. Later in the afternoon the buildings of the University College of South Wales were inspected, and in the evening the members attended a reception and dance in the City Hall by invitation of the Lord Mayor of Cardiff.

On Wednesday members had a choice of spending the whole day at Ebbw Vale, where the works of Richard Thomas and Co. were inspected, or of visiting certain local works in Cardiff during the morning and of attending in the afternoon a garden party at Cardiff Castle by invitation of the Marquess of Bute. In the evening the Institution dinner was held in the City Hall, and following it there was dancing until midnight. Thursday was devoted to a whole-day visit to Swansea and district, where during the morning visits were paid to steel works, nickel works, oil refineries, and other establishments. In the afternoon, following a visit to the Swansea Civic Centre and Guildhall, the members proceeded by motor coach for a tour along the Gower Coast to Langland Bay, where they were entertained to supper and a dance by the South Wales Siemens Steel Association. To-day, Friday, is being given over to whole-day excursions to the Wye Valley, or, alternatively, to Minehead and Exmoor.

About 200 members attended the meeting, together with about 130 ladies. We hope to give a fuller account of the proceedings in next week's issue.

(To be continued.)

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

CHEAP ELECTRIC LAMPS.

SIR,—I have read with much interest the remarks made at the Torquay meeting of the I.M.E.A. by the President anent cheap electric lamps.

I confess without shame that, whilst I am not one of the poor to whom Mr. Bache referred, I always buy cheap lamps, and I buy them not because they are cheap but because I find them at least as reliable as high-efficiency lamps made to the B.S.I. specification. My experience with the latter has not been happy. In every house there is, no doubt, a certain amount of surging, and it seems that the cheap lamp, which is probably run at a lower efficiency—that is to say, with a greater factor of safety—stands it better than the more expensive one. Speaking as a householder, I find it of far greater importance that the lamps should be trustworthy than that they should be highly efficient, and in consequence make it a practice to buy lamps rated 10 volts higher than the nominal supply pressure. The price of juice is now so low in my district that the difference in the quarterly bill is insignificant by comparison with the relief from the irritation which the sudden failure of a lamp causes.

It is good news that lamp makers are following the lead given by Crompton's some few years ago, but it is to be hoped that they will go a great deal further and let us have British lamps at 6d. apiece. That may call for a revised B.S.I. specification, but that will be well worth while if we can regain the trade which, according to Mr. Bache, is now going to foreign makers to the tune of £200,000 a year.

May 30th. HOUSEHOLDER.

SIXTY YEARS AGO.

ON Friday morning, May 31st, 1878, a squadron of German ironclads consisting of the "Grosser Kurfürst," the "König Wilhelm," and the "Preussen," were, in the order named, steaming in line off Folkestone in a calm sea and under a bright sun. Between the first and second ships there was a distance of about 110 yards. The speed of the squadron was about 8 knots. Two small merchant ships—sailing vessels—endeavoured to cross the bow of the leading warship which, following the rule of the sea, gave way and endeavoured to pass under the stern of the merchantmen. The second warship tried to follow this manœuvre, but either the order issued was misunderstood or was delayed in its execution, or the steering gear failed to act properly. The "Grosser Kurfürst," seeing her danger, endeavoured to escape from it by steaming full speed ahead, while her consort, the "König Wilhelm," put her engines full speed astern. The distance separating the two ships was, however, insufficient. The bow of the second ship struck the side of the leader at an angle of 45 deg., the estimated relative speed at the moment of collision being 3 knots. Within ten minutes the "Grosser Kurfürst" turned completely over and sank, carrying to their graves nearly 300 of her complement of 500. In our next succeeding issue, June 7th, we published engravings of the bow of the "König Wilhelm" after she had been dry-docked at Portsmouth. Commenting in a leading article on the disaster, we remarked that its circumstances closely resembled those under which a year or two previously the "Iron Duke" had rammed and sunk the "Vanguard." There was little, we said, to learn from either mishap on the navigational side, except the obvious lesson that ironclads could not be packed closely together without imminent risk. On the constructional side, however, the German mishap was very instructive. The condition of the bow of the "König Wilhelm" after the accident revealed the fact that she was saved from following her consort to the bottom only because of the calm weather which prevailed at the time. Her ram had been twisted nearly 6ft. to one side, her bow plates had been ripped and torn, and through the rent water had poured into her fore compartment. If that damage could be done by a blow delivered at a speed of about 3 knots, what damage, we asked, would an attacking vessel suffer if she rammed an enemy at full speed? The "König Wilhelm," we recorded, was built to the designs of Mr. E. J. Reed for the Turkish Government, but was sold to Germany before she was completed. The design of the ram was one commonly followed, but it was now obviously proved to be weak. It was true that in our latest warship, the "Inflexible," the ram had been strengthened by supporting it from the armour-plated deck. Nevertheless, the German disaster would, we thought, do much to discredit the ram as a weapon of naval warfare. Those who still favoured it would have to cease regarding it as an all-powerful device which could be used with impunity against a foe. In actual warfare it would probably prove as fatal to the ship which did the ramming as to the ship which was rammed.

THE SHORT-MAYO COMPOSITE AIRCRAFT.—According to an announcement of Imperial Airways, it is expected that the upper component of the Short-Mayo composite aircraft will fly to Canada next month. The machines have completed their airworthiness tests. Before its flight the "Mercury" is to make a flight round Britain, and it will also be fitted with new engines.

Visit to the Lincoln Works of Ruston and Hornsby, Ltd.

THE steadily increasing demand for oil engines has necessitated a considerable amount of reorganisation and modernisation at the works of Ruston and Hornsby, Ltd., and during a recent visit to Lincoln we had an opportunity of seeing the latest methods of production adopted by the firm. All the standard ranges of engines are now being built on a production basis, and to enable rapid assembly, with the minimum of fitting, all parts are made to the finest practical limits.

The principal object of our visit was to inspect a shop recently laid out for the production of small vertical oil engines and the extensions and improved mechanised methods adopted in the foundry.

A brief tour was first made of the various machining and erecting shops in which the components of the larger engines are made and assembled. In the light machine gallery, which, incidentally, is one of the oldest in the country, a number of new machine tools has been installed for the production of small oil engine details. In this section a few of the older types of machines which have been retained have been modernised for the making of certain special parts to the fine limits now demanded. In the heavy machine shops where the larger engine parts, such as bed-plates and housings, crankshafts, fly-wheels, cylinder heads, liners, &c., are made, many old machines, which in most cases have been modernised, are still working side by side with the newer high-speed machines. Although some of the older machines are somewhat slow, they have been for the most part set up for certain special jobs, for which it would not be an economical matter to use the later types of machines.

At one end of the heavy machine shop is a well-equipped tool-room in which all the jigs and tools used in the works are made. All the engine bearings are made in a special shop. Here the bearings are first tinned and the anti-friction metal is then spun on to them to the required thickness. The bearing metal is not keyed to the shell, as the method of running the metal provides a perfect bond.

In the adjoining forge we saw forgings of all types being made on a large battery of drop hammers, which included some of the latest machines for that class of work.

It was in the erecting shops that the advantages of the high degree of accuracy maintained in the fabrication of engine parts was most evident. Here the necessity of hand fitting has been virtually eliminated and the fitting department has been practically dispensed with. The shop has been divided up into sections, each of which deals with one type of engine. Fig. 1 shows the section in which the larger vertical engines are assembled, and the orderly manner in which this section is laid out is typical of the other erecting bays. In addition to a number of overhead travelling cranes for the heavier lifting, each section is well equipped with smaller lifting devices.

A department of considerable interest is that where the fuel pumps and atomisers are made and assembled. For this work the company has installed special machinery, much of which is of its own design, and the method of manufacture provides interchangeability of parts. A practice of continually checking parts during their production by inspectors in the centre of the shop has been adopted to maintain the high standard of accuracy required for this class of work.

It was in the test shop that the best impression of the wide range of oil engines that the company makes was obtained. Here there were being tested numbers of different sizes of marine and land engines, excavator engines, and single and multi-cylinder horizontal engines for a variety of jobs.

The company trains its own apprentices in a small department adjoining the erecting shop, where the newcomer spends from six to nine months learning the rudiments of his trade.

The New Small Engine Shop.

During the past few years the company has designed and produced a new range of small vertical oil engines. These engines are made in three cylinder sizes—3½ to 4, 5 to 6, and 7½ to 8¼ B.H.P. at 1000 r.p.m. The smallest is made in single-cylinder units only; the 5 to 6 B.H.P. in single and twin-cylinder units; and the 7½ to 8¼ B.H.P. in single, twin, three, and four cylinders, giving a closely graduated range from 3½ to 30–33 B.H.P. For the manufacture of these engines it was decided to lay down an entirely new and self-contained plant, and the site chosen was that of an old foundry which had been replaced in another part of the city. The bay of the original pattern shop was retained and fitted up as a machine shop, shown in Fig. 2, the remainder of the building was demolished, and the new shop, part of which is shown in Fig. 3, erected. All machines installed in the new shop are of the latest types, and modern methods of quantity production have been instituted. Owing to the fact that all work on the engines from machining to testing is done under one roof, it has been possible to lay the plant out to maintain an even flow of work through the shop.

All the heavier castings to be machined, such as housings and cylinder heads, are delivered at the far end of the shop, shown in Fig. 2, and after each successive operation are passed to the next machine on a roller conveyor which serves the whole line of machines. Before the housings are delivered, they are water tested in the unmachined state to eliminate wastage in machining on faulty castings. The first operation on the housings is done on four Cincinatti duplex "Hydromatic" milling machines. The first machine mills the top and bottom faces, the second the sides, the third the ends, and the fourth the faces, on which the fuel pumps are mounted. From the milling machines the housings are passed on to three Asquith boring machines, on which the cylinders are machined for the reception of the liners, the main bearings, and camshafts. All the holes in the housings are then drilled and tapped on three Archdale radial drilling machines, each of which works with two tables. In this manner, whilst drilling and tapping of one part of the housing is proceeding on one table, the previous housing is being mounted on the second table. When all machining operations are completed the housings are carried away from the end of the conveyor by means of an overhead mono-rail to the degreasing plant, and thence to the erection conveyor.

The machining of the cylinder head castings is organised in a similar manner. After being milled on two of the machines the heads then pass to the multiple drilling machines, where the straight holes through the head are drilled. The head then passes on to an Archdale vertical-spindle machine to have a copper sleeve spun into the atomiser hole, to have the valve seat cut and the valve guides finished.

The blanks for the connecting-rods are drop stampings from the company's own forge, and at the first operation the two sides of the big and small ends are milled. In successive operations the bolt head and nut faces are milled, the bolt holes drilled, and the big end bearing roughed out. Since the blank is forged with the bearing cap in one piece with the rod, an elongated hole has to be cut with the two ends forming semi-circles with a straight length at the sides corresponding to the amount which is cut out when the cap is separated from the rod. In order to make the hole this shape an excentric is arranged underneath the work to move the connecting-rod laterally by $\frac{3}{16}$in., which is the amount lost when the cap is cut off. A machine has been adapted to cut off the bearing caps twelve at a time and accuracy in cutting is assured by the use of a special jig. The cap is then bolted on to the rod and the bores for the big and small end bearings are finished.

The phosphor-bronze bush forming the small end bearing is pressed into place and the white metal big end bearings are placed in position and the rod once more bolted up complete. Both bearing surfaces are finished simultaneously in a two-spindle diamond drill in order to avoid the necessity of hand scraping.

In the making of the crankshafts the first three machines shape the webs of shafts for single-cylinder, twin-cylinder, and four-cylinder engines, the forgings being mounted on the machines two at a time. The chamfered ends of the web are shaped on an adapted slotting machine. The webs of three-cylinder crankshafts are shaped on a milling machine which has been installed especially for the purpose.

The remaining machines in the shop are engaged upon machining the multiplicity of small parts required for these new engines, and include a battery of Ward automatics for parts machined from the bar.

FIG. 1—ERECTING SHOP FOR LARGE VERTICAL ENGINES

FIG. 2—SMALL ENGINE DEPARTMENT MACHINE BAY

Engine Erection.

In describing the erection of these engines a single-cylinder unit is taken as an example, but it will be seen that the multi-cylinder engines offer no special problem. The number of parts in a single-cylinder engine of this type is 523, which are grouped into twenty unit assemblies. These assemblies are built up at tables laid out for the purpose at one corner of the shop and are taken from these tables into the finished unit stores. The details for unit assemblies are drawn from finished part stores in batches of twenty.

To eliminate the handling of numerous details in the shops skips are loaded by the stores and conveyed by a jacking truck to unit assembly benches. Fitters work from these skips, placing finished units in another skip for transport to the stores.

The stores, which are maintained at an even temperature and free from dampness, are equipped with steel bins for the storage of details and finished units. Every detail has a separate division in the bin and all details and units are carried on a maximum and minimum stock basis to ensure a consistent supply of material to fitters and the prompt supply of spares.

Engine erection is carried out on the conveyors shown in Fig. 3. The housings, after leaving the machine bay, pass through the degreasing plant, then on to the conveyor for the first assembly operation, where studs and liners are fitted and a water test is made. They then pass along the conveyors to the erectors for final assembly of units, which are issued by the stores in batches of five complete sets. The figure five has been arrived at by taking into consideration the size of skip required by largest unit, namely, the crankshaft. Crankshafts are only handled individually by the detail fitter and erector, who are responsible for the protection of the ground surfaces. The final erection is done in four stages: first, fitting of the crankshaft and cam shaft into the housing, and fitting of end cover and oil seal, all details having

been first thoroughly washed in paraffin and dried by compressed air. At the second operation the connecting-rod, piston, lubricating pump, sump, and bearer bars are fitted. The engines then pass to the third operation for the assembly of cylinder head and fuel pump, tappets, push rods, and the timing. The fourth operation is the fitting of the atomiser, top covers, fuel and oil pipes, and keying up the flywheels.

The completed engines are run off the conveyor track on to special trucks for transport to a painting booth at the end of the shop. After the paint is dry the engines are put on test.

The test benches, illustrated in Fig. 4, are equipped with Perry's brakes, and the engines are given a full load test to satisfy the requirements of the B.S.I. 12-hour rating. Full and no-load tests are also given to prove governing. The circulating water can be controlled to flow at any given temperature, and we were informed that the whole of the test equipment, including the exhaust system, can be readily arranged to coincide with any installation requirement or climatic condition.

The Foundry.

Situated in another part of Lincoln is the grey iron foundry of Ruston and Hornsby, Ltd., which during the past two years has been extensively reorganised and mechanised in order to cope with the variety and large numbers of castings required for the company's many products. This foundry is divided into six main sections :—Core-making, main foundry, mechanised foundry, fettling department, core sand recovering section, and patternmaking department.

Core Production.

In the core-making department it was found advisable to develop two separate sections, one for making the large heavy types of cores and the other for the small and medium sizes. In these departments all the actual core-making is done by female labour, in both natural bonded and oil sands, whilst all the heavy lifting work is done by men. The heavy section is in one separate shop, 150ft. long by 50ft. wide, and served by a 3-ton overhead crane. The cores are dried in three stoves, of the company's own design, which are fired by one "Acme" type fire-box.

The arrangement of the light core shop may be seen in Figs. 7 and 8 on page 622. Here it will be seen that the core-making is done on a series of benches running across the width of the shop. These benches are served by a roller conveyor round the walls upon which the finished cores are placed for transport to the large continuous drying stove, shown in Fig. 8. This stove is able to handle cores up to 5ft. 6in. by 20in. by 20in., and at its discharge end the dried cores are unloaded on to another roller conveyor which distributes them to the core dressers and finishers. The finished blacked cores are then loaded on to another roller conveyor, which takes them to a second continuous stove, where the wet blacking coating is dried. The core plates are returned to the core-making shop on the roller conveyor shown on the left of Fig. 8. Incorporated in the finishing department is a section in which individual cores are assembled into complete units. For this work metal jigs and fixtures are used to ensure dimensional accuracy and reduce the likelihood of errors in assembly to a minimum.

A large number of small cores are made in a core-blowing machine to be seen in the left foreground of Fig. 7. In order to handle the large number of existing core boxes, the company has developed a new type of back blowing plate, and it is now possible to have six or more different boxes in production at the same time without necessitating alterations to the machine.

Main Foundry.

The main foundry consists of two large bays, each 600ft. long by 50ft. wide. One of these bays, shown in Fig. 9, is served by six heavy overhead travelling cranes, and is devoted to the heavy work, including large oil engine housings, bed-plates, flywheels, &c. At present ramming is being carried out by two portable sand slingers and two large bumpers, but an entirely new arrangement is in course of erection. By this arrangement a motive type sand slinger will serve the whole of the bay shown and part of the other. In order to overcome the difficulty of the long distance it would be necessary for the machine to travel to refill with sand, an arrangement is being incorporated for the slinger to have sand available at any point along the 600ft. length of shop. Instead of the usual overhead hopper sand supply, an overhead endless feeding belt, immediately over the slinger track, is to be installed. Plough points will be located at 8ft. intervals, and by regulating these points the slinger storage hopper can be continuously filled at any part of the track during actual slinging and the arrangement also allows for trimming the sand in the slinger hopper.

Handling of used sand is by means of an underground return belt running the whole length of the shop, each moulding floor having its own knock out. It was considered that a central knock-out station in such a long shop would cause too much disorganisation, particularly with the cranes. The return belt conveys the sand to a cleaning and preparing plant, which consists of an existing complete No. 2 August Simpson mill, screen, magnetic separator, and storage hopper, and a new No. 3 August Simpson mill and storage hopper. The mills discharge on to belt conveyors to a hopper having a rotary plate from which the sand is ploughed off on to the main overhead distributing belt to the sand slinger.

The small mill can be arranged for either mixing special facing sand or the bulk slinger sand. When facing sand is made, the swinging belt conveyor discharges into tubs which are then taken by overhead Morris telphers to any point in the shop. When this mill is engaged on the bulk sand the conveyor is swung, so that discharge is delivered into the hopper feeding the slinger belt.

The whole of the sand-distributing and preparing plant has been supplied by Augusts, Ltd., of Halifax.

Mould drying is carried out by means of eight large stoves, situated at convenient points round the shop, each heated by "Acme" coke-fired, forced draught fire-boxes, made by the Foundry and Engineering Company, Ltd., West Bromwich. Four of the stoves are equipped with frictionless bogies supplied by the same company. Temperatures are controlled by Cambridge recording thermometers on each individual stove.

A special feature in this department is the number of jigs and templates supplied to the moulders with every job for use in the "coring up" operations. They are stamped with the pattern number, and are, in fact, looked upon as part of the pattern tackle. The foot rule for core-location purposes has been completely dispensed with. By the means adopted accurate locations are obtained, subsequent machining operations are simplified, and the production of interchangeable parts ensured.

The melting equipment for the main foundry consists of the two 9-ton per hour cupolas and one 4-ton per hour cupola, shown in Fig. 10. The two large cupolas are of the balanced blast type and are blown alternate days. This method of alternate working ensures good condition, as each is carefully repaired and overhauled after its day's run. All three cupolas operate on a continuous tapping principle, being fitted with tilting spouts. The cupolas have only one tap hole each, through which metal and slag is tapped, the slag being automatically separated in the cupola spout. This arrangement has been in successful operation on these cupolas for at least eighteen years. The whole of the melting operations is controlled by a branch laboratory situated in the foundry, which deals only with foundry materials and problems. In this way a continual check on work is maintained, resulting in accurate control and uniformity of quality.

The 4-ton per hour cupola is used solely for special metals and is in continual operation. This method ensures absolute control and removes any possibility of contamination with the general iron mixtures. All cylinder heads, for example, are cast with metal melted in this cupola, and the metal produced is one of the company's specialities, which has been proved over a period of years to be eminently successful for the purpose.

Over 100 tons of molten metal per day is handled in this section, and castings varying from 10 cwt. to 20 tons are produced. We were informed that as many as 130 cores are assembled in one mould for certain jobs and 90 per cent. of the work produced is subsequently subjected to pressure test after final machining.

Mechanised Foundry Department.

The mechanised section of the foundry has been developed mainly for the batch production of small and medium section green sand castings. Here the eight moulding machines, shown in Fig. 11, are fed with prepared sand by an overhead belt, from which the sand is ploughed off by scrapers operated from the floor level. Two other stations, the hoppers of which are fed by sand from the overhead belt, are engaged in hand ramming on odd jobs. After ramming, each half mould is placed on the short roller conveyor in front of the machine and then cored, closed, and clamped. The boxes are then placed upon the plate conveyor and weighted ready for transport to the casting station. At the casting station, shown in Fig. 12, ladles, with a capacity of up to 5 cwt., are operated by one man with the aid of an air hoist and an overhead runway. Whilst the pouring operation is proceeding the conveyor is stationary and the ladle is emptied along a set length of boxes. The operator, on completing the pouring, takes the ladle back for refilling and just before he returns a warning hooter blows and the plate conveyor is started up to bring a fresh batch of boxes from the moulding machines to the casting station. At the end of the conveyor is a knock-out station, where the moulds are pulled off. Here the sand drops through a floor grid and is returned to the sand preparing plant by a moving belt. Before admittance to the preparing plant the sand is passed through a cleaning unit, which comprises a magnetic separator, screen, and a dust and silt extractor.

The sand conveying and preparing plant, which was installed by Augusts, Ltd., includes an underground sand spillage belt conveyor installed alongside the ramming stations, which links up with the knock-out sand belt. Sand from both these conveyors discharges on to an inclined belt leading to the cleaning plant. The cleaned sand is discharged on to a second inclined belt and taken to the storage hopper over a No. 3 August Simpson mill. The requisite quantity of cleaned sand is charged into the mill and new sand added to the batch charge by means of a bucket loader. After mixing, the 1-ton batch of prepared sand is discharged from the mill into a hopper underneath, having a rotary table feed, from which it is ploughed off on to a disintegrator.

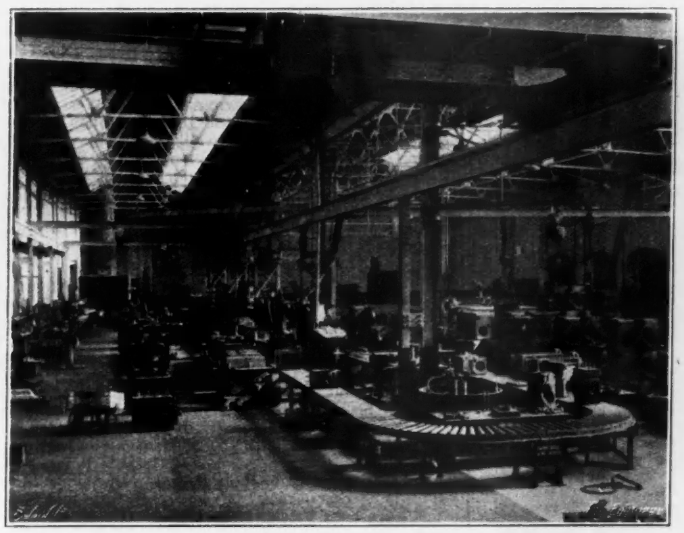


FIG. 3—SMALL ENGINE ERECTION DEPARTMENT CONVEYOR

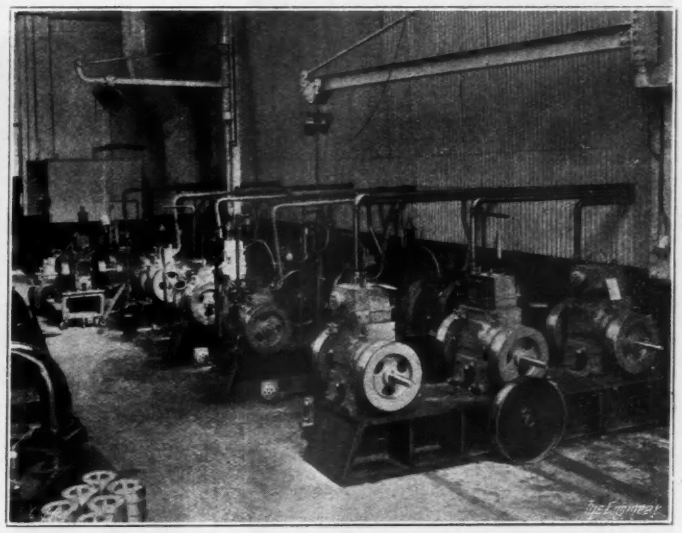


FIG. 4—SMALL ENGINE TEST BEDS

and in this way a continuous sand discharge on to the main sand distributing belt is obtained.

For castings requiring special metals a separate roller conveyor system of horseshoe shape is used. The moulds are rammed on an adjacent machine and are cored, closed, and cast on this roller conveyor. This arrangement enables the special metal brought from the main foundry cupola to be cast in batches instead of having such special jobs coming along irregularly on the main plate conveyor. This conveyor is on the same casting line as the main plate conveyor, and the same casting procedure is employed as described previously. Cast moulds are pushed up to the central knock-out station and exactly the same procedure for disposal of castings, sand, and empty boxes applies, as outlined in connection with the mechanised section.

At the far end of the shop there has been installed a sand slinging plant, which can either be used for the larger-sized green sand oddments or for batch production of medium-sized work. The slinger is supplied from the main bulk sand ploughed off the overhead belt into a hopper.

This mechanised foundry has now been successfully working for two years and regularly handles 20 tons of molten metal per day producing green sand castings varying from 1 oz. to 2½ cwt. The molten metal is provided by a 3½-ton per hour capacity cupola, which delivers into a ladle receiver, from which the casting ladles are filled.

The Fettling Shop.

The fettling shop consists of two bays, 60ft. wide by 150ft. long, and is divided roughly into two sections,

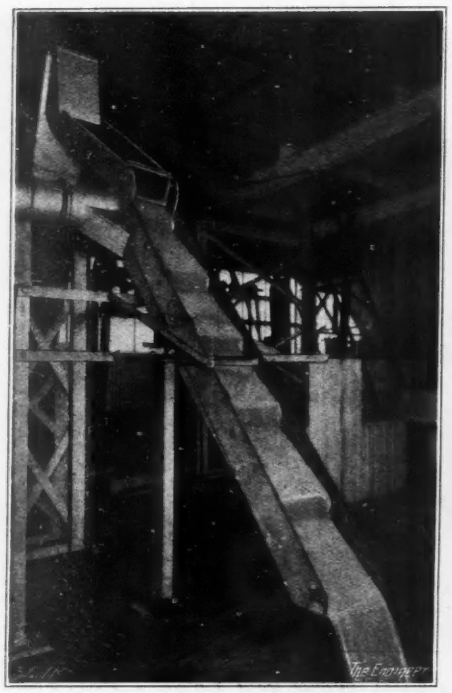


FIG. 5—SILT EXTRACTION CHUTE

a light section dealing with all castings that can be handled without the use of a crane, and a heavy section equipped with two 5-ton overhead cranes.

The light castings are despatched from the foundry on a telpher crane and tipped in the fettling shop at the end of a belt conveyor, which feeds them into a rotary barrel shot blast machine. This machine, made by St. George's Engineers, Ltd., revolves at 3 r.p.m. and automatically discharges the castings at the rate of 2½ to 3 tons per hour. After fettling all castings are inspected before being batched up for despatch. All castings that will not be in contact with oil are painted before despatch in a dipping tank, and the castings are then ready for storage at the various works.

Castings are delivered to the heavy section by rail, the overhead cranes having gantries outside the shop to serve the unloading and also the coring operations. The castings are cored over the conveyor feeding the sand reclaiming room and then taken into the shop for shot blasting. The machine used for this work consists of a large chamber, 25ft. long by 10ft. wide, placed at right angles to the cranes, having doors in either bays. Two bogies are used, one for each bay, and by this method one can be unloaded and reloaded during the blasting operation; by this means the plant is worked to its utmost capacity.

For the fettling operations the men are in gangs of two or three and each gang is equipped with a pneumatic chipping hammer and high-speed portable grinder. All fettling is on a piecework basis, a rate per ton of castings produced in all cases being paid. It would, of course, be impossible to give an all-round rate, as the type and size of castings varies considerably, so a system was devised splitting up the products into roughly twenty different sections and a price per ton being paid for each group.

A large dust arrestor is installed in the shop to deal with the large room shot blast, the continuous barrel blast, and all the stationary grinding wheels. This plant, which is roughly 22ft. long by 13ft. wide, and of the bag type, deals with 15,000 cubic feet of air per minute, the discharge being on the outside of the shop.

Core Sand Recovery Department.

A process of core sand recovery has been developed by the company's staff as a result of laboratory research work extending over the past eighteen months. Used silica core sand is now efficiently reclaimed on a large scale and after mixing with core oil compound made into satisfactory cores equal in every way in quality to those made from new sand. In fact, it is claimed that the old sand cores are superior, particularly in regard to increased green bond strength and permeability.

The laboratory researches showed that dust and silt (*i.e.*, through 120 mesh) was the main factor influencing the properties and behaviour of re-used oil sand. At one time it was generally considered that roasting at a high temperature was essential if silica sand was to be recovered, but experiments showed it to be unnecessary. In point of fact, heating of any description was found to be unnecessary, but passage of the sand through a rotary drier was found to assist in separating any silt which might be adhering to the sand grains. Owing to the nature of the work produced in the Lincoln foundries, calling for collapsible cores and also to oil sand suiting the female coremakers, the daily consumption of silica sand is as much as 10 tons per day. The recovery of this quantity, therefore, represents a very considerable saving, particularly when dumping costs and facilities, together with the initial cost of new sand, is taken into account.

Cores are knocked out from the castings on a grid from beneath which an underground belt conveyor, passing over a magnetic separator, takes the sand to an elevator, which delivers it into a rotary screen where

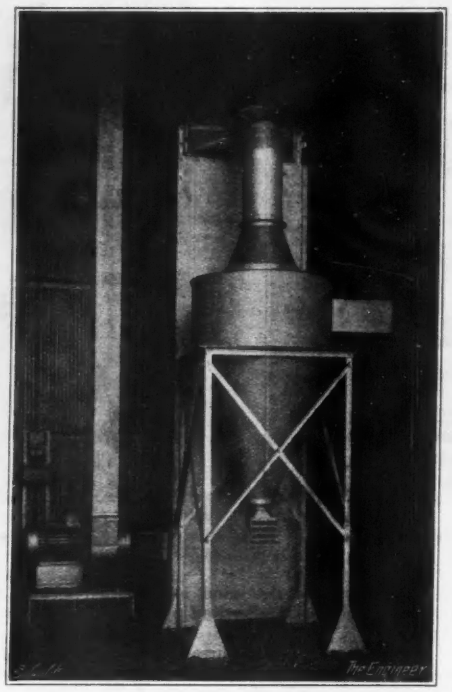


FIG. 6—CYCLONE AND BAG FILTER

tailings are rejected and the screened sand delivered into an overhead storage hopper. The sand is discharged from the hopper continuously into a grinding mill and then passes to the boot of a second elevator, which takes it to another overhead storage hopper. From here it continuously discharges into a Pneulec rotary drier and is subjected to heating and prolonged friction to separate silt from the sand grains. The dried sand is then elevated and dropped on to the specially designed chute, shown in Fig. 5, made for this purpose by Standard and Pochin Bros., of Leicester. It consists of a channel-shaped chute having four weirs, over which the sand cascades in the form of waterfalls. As the curtain of sand passes over each chute it is subjected to a controlled air suction from the cyclone and bag filter in the adjoining room, shown in Fig. 6, where the silt is collected. The recovered sand from the bottom of the chute is loaded into a bucket loader serving two Rotoil oil sand mixing machines, where the oil sand is prepared and then delivered to the core shops by an Aveling and Barford dumper.

Pattern Shops.

The pattern shop is a single-storey building, comprising two bays, each 220ft. long by 50ft. wide. The all-glazed roof and large windows admit the maximum daylight, and large doors at either end permit easy access of large patterns to and from the foundry. Four lines of benches are each served by an overhead runway with a 15-cwt. block for handling the larger patterns. The large number of modern machines are all driven, with the exception of a cross-cut saw and the lathes, by an underground shaft running the entire length of the shop. The shaft is in three sections, each of which is driven by a separate motor. Wood refuse from the machines is taken directly to the boiler-house by means of a suction fan connected to a large central duct which has branch connections to each machine.

The whole of the patternmaking for Lincoln, Grantham, and the associate firm, Ruston-Bucyrus, Ltd., is done in this shop. The class of work naturally varies a great deal as regards size and design, which varies from small patterns to produce castings of only a few ounces weight to large patterns for bed-plates and housings weighing up to 20 tons. The coring of some of these moulds is so intricate that full sets of jigs for setting cores in the moulds are provided, also rubbing jigs to ensure cores are correct to shape and size. Many patterns are made for steel castings, and some of these embody as many as over 100 cores in some of the large bed-plates and truck frames.

The paint shop is a special chamber fitted up with ventilating fan. Large patterns are spray painted, and a colour scheme has been adopted for the various parts.

As modern machining methods call for a much finer machining allowance than formerly and the design of castings is generally more intricate, inspection has to be very thorough. A section of the shop is fitted up with surface plates, scribing blocks, and vee blocks, &c., and a staff of inspectors check each pattern.

Ten to twelve patternmakers are kept continuously employed in the production of metal patterns and core boxes. Wherever the quantities required warrant, the patterns are made in either cast iron, brass, aluminium, or special zinc alloy pattern metal. One man is kept solely employed in fixing and fitting metal inserts in the larger-sized pattern and core boxes. Most of the pattern and core box tackle for the large oil engine work consists of composite wood and metal.

INSTITUTION OF ENGINEERING INSPECTION.—At the annual general meeting of the Institution of Engineering Inspection, held at St. Ermin's Hotel, Westminster, S.W.1, at 5 p.m. on May 26th, 1938, the following were elected for the coming year to fill the places vacant by rotation:—President: Lieut.-Colonel H. W. S. Outram, F.R.Ae.S., A.M.I.E.E.; Vice-Presidents: H. R. Cotterell and H. V. Senior, M.I. Mar. E., M. Inst. Fuel. Ordinary Members of Council: A. J. Bird, M.I. Loco. E., P. W. Crabtree, A.M.I. Mech. E., M.I. Mar. E., Damer Dawson, Colonel K. F. Dunsterville, S. E. Goymour, Captain E. R. D. Long, R.N., Major H. Myers, Captain C. B. M. Platt, M.I. Min. E.

DEATH OF MR. J. DYAL.—It is with regret that we note the death of Mr. James Dyal, who was in the service of Thos. W. Ward, Ltd., for fifty-four years and a local director for nineteen years. He was well known in industrial circles in all parts of the country, especially in the iron, steel, and allied trades. Until a serious illness resulted in his semi-retirement three years ago, he travelled many thousands of miles yearly both in this country and abroad in connection with the dismantling and development of industrial properties. His career began when the scrap trade was mostly local, and in the course of his service he inspected many of the famous ships and works which have been purchased and dismantled by Thos. W. Ward, Ltd.

SAFETY RULES FOR USE IN CHEMICAL WORKS.—In 1928 the Council of the Association of British Chemical Manufacturers decided to draw up and issue to its members, in provisional form, a set of model Safety Rules for use in Chemical Works. These rules were based on the Factory and Workshop Act, the Chemical Works Regulations, the Electricity Regulations, and similar statutory provisions, together with a number of other desirable precautions which had resulted from experience. Part I Model Rules, was completed and issued in provisional form early in 1929, and has just been issued in final form, including the provisions of the new Factories Act, 1937. It is in the nature of an introduction to Part II, the first section of which was issued in 1929, and which it is hoped to revise and complete also for issue at an early date.

THE CORROSION OF TAR STILLS.—The Department of Scientific and Industrial Research has issued a report of an investigation, carried out at the Chemical Research Laboratory on behalf of the Association of Tar Distillers, into the causes and prevention of the corrosion of tar stills. After an exhaustive examination of a long series of tar fractions, the following conclusions were reached. The corrosive effect of neutral and basic constituents was negligible, but at high temperatures resinols or petroleum insoluble phenols were very active in promoting corrosion, and in the presence of ammonium chloride the activity of those materials was intensified. The more volatile phenols were not corrosive, a fact which is confirmed in industrial practice where tar acid stills have a very long life. Confirmation of the conclusion that the corrosive effect of any tar is dependent chiefly on the content of benzene soluble resinols was obtained by comparative distillations of four tars. The report states that the possibility of developing a technique whereby the resinoid portion of tar may be precipitated and only the oily fractions of the tar submitted to distillation was explored. A long series of distillations in experimental stills carried out on the petroleum extract of a corrosive tar established that the corrosion caused by this material is much less than that manifested by a so-called non-corrosive tar under comparable conditions of distillation. A series of tests on selected metals and alloys indicated that nickel-chromium-molybdenum steels were quite unattacked by resinols alone and only slightly by resinols in presence of ammonium chloride. Nickel and nickel alloys were also very resistant.

Rail and Road.

OPENING OF A NEW SOUTHERN RAILWAY SUBURBAN LINE.—On Sunday, May 29th, the first section of a new suburban line of the Southern Railway, which will eventually run from Motspur Park to between Ashstead and Leatherhead, was opened between Motspur Park and new stations at Malden Manor and Tolworth. A second section to Chessington Court and Chessington Grange will be opened in about a year's time.

S.R. WEED-KILLING TRAIN.—The weed-killing train of the Southern Railway Company, which consists of eight vehicles containing enough chemical concentrate for 96 miles and water for 50 miles, is shortly to go into service. By means of two pumps the water and chemical are mixed in a central chamber and the solution passes to the nozzles at a pressure of approximately 25–30 lb. per square inch. The train travels at 25–30 miles an hour, and covers about 1400 miles in six weeks. The operators live on it. The solution used is of a non-poisonous chlorate type; it is toxic only to all forms of plant growth.

A PROPOSED ROAD IN ONTARIO.—A proposal has been made to the Ontario Government by a financial group in New York for a new road to span the southern part of Ontario and link up Detroit, Mich., with Buffalo, N.Y. The road, which would cost about 30 million dollars to build, would provide a short cut for motor traffic between Midwest Central and the Eastern United States by eliminating the present route around the southern edge of Lake Erie. It would be in the form of a two-lane express highway and enable traffic to traverse the 240 miles between the Ambassador Bridge at Detroit-Windsor and the Peace Bridge at Fort Erie without a stop.

PROPOSED NEW LINES IN FINLAND.—It is announced that the Finnish State Railways is to build some 400 kiloms. of new lines during the next seven years at a cost of 80 million marks annually. Amongst the proposed new lines are the following:—Joensuu-Illemantsi, a distance of 71 kiloms., costing 101 million marks; Orivesi-Jamsa, 66 kiloms., at a cost of over 92 million marks; Haapavesi-Saarijarvi, 75 kiloms., costing 91 million marks; Seinajoki-Parkano, 89 kiloms., costing 98 million marks; and Siilijarvi-Syamajarvi, 100 kiloms., costing 145 million marks. During 1937 the total length of new lines opened was 116 kiloms., making a total gross length of open line at the beginning of this year of 5483 kiloms.

LONDON-WORTHING ROAD IMPROVEMENTS.—The construction of the Mickleham By-pass on the London-Worthing Road, now nearing completion, is to be followed by the modernisation of a section of the old road, about two-thirds of a mile long, from the southern end of the by-pass to a point a short distance beyond Pixham-lane. A grant from the Road Fund towards the cost of the work, estimated at over £30,000, has been made to the Surrey County Council by the Minister of Transport, and the work will be put in hand as soon as the necessary land has been acquired. The length of road concerned lies at the foot of Box Hill, where it is proposed to widen the road to 120ft. and provide dual 22ft. carriageways, two cycle tracks, 9ft. wide, and footpaths 6ft. wide.

NEW CENTRAL ARGENTINE RAILWAY SERVICE.—A new bi-weekly *de luxe* service has been inaugurated between Buenos Aires and Cordoba by the Central Argentine Railway. The new train, known as "El Cordobes," is composed of four silver and blue coaches and two dining cars reconstructed from carriages in normal service on the Central Argentine line, and carries 224 passengers 450 miles in 9¼ hours, including one stop of fifteen minutes at Rosario. This represents an improvement of two hours on the time taken by the ordinary expresses in service on this route. The new coaches, which are air conditioned and dust-proof, contain baths, ice water for drinking, two cocktail bars, and two restaurants. The air conditioning apparatus is electrically controlled and there are filters installed between the double roofs of the carriages.

THE FIRST RAILWAY "RATES WAR."—The world's first "war" of railway rates is recalled by the centenary of the opening of the Manchester and Bolton Railway, now part of the London, Midland and Scottish Railway Company's system. The opening of this railway from Manchester to Bolton on May 29th, 1838, was followed less than a month later by the opening of a line belonging to the Bolton and Preston Railway, from Chorley to Euxton Junction, which afforded the traveller a choice of routes between Manchester and Preston. The new route *viâ* Bolton was 6 miles shorter than that over the Liverpool and Manchester and North Union Railways *viâ* Parkside, and competition between the two routes led to the fares between Manchester and Preston by both routes being rapidly cut from 7s. 6d. (first class) and 5s. (third class) to 3s. and 2s. respectively. Furthermore, in order to offset the shorter journey of its competitors, the North Union Railway purposely delayed the Bolton and Preston trains which used, by running powers, the North Union tracks between Euxton Junction and Preston, the North Union receiving a toll of 1s. for every passenger. This "blockade" became such a nuisance that the Bolton and Preston Railway inaugurated a service of road coaches between Euxton and Preston, and also took steps to revive their powers to convert a canal into a railway for this distance, and so obtain a line independent of the North Union. Finally the "war" was ended by compromise, whereby an amalgamation was arranged. The Manchester and Bolton Railway developed out of the Manchester, Bolton, and Bury Canal, which was opened for traffic in 1796, and which was used for both goods and passenger traffic, the latter being catered for by "Canal Packets," which were taken off and sold in March, 1838, as they did not pay and their speed damaged the banks. Following the course of the canal for part of the way, the Manchester and Bolton Railway was opened on May 29th, 1838, part of the line being laid on stone sleepers. The estimate for the railway was £300,000, but the actual cost exceeded twice that sum, or £60,000 per mile. Early engines for the railway were supplied by Edward Bury, of the Clarence Foundry, Liverpool, the engines being named "Fairfield," "Victoria," "Bolton," and "Manchester." In 1846 the Manchester and Bolton was absorbed by the Manchester and Leeds Railway, which a year later became the Lancashire and Yorkshire Railway, and is now part of the L.M.S.

Miscellanea.

LONDON FIRE BRIGADE.—It is announced that Commander Firebrace is to succeed Major C. C. B. Morris as Chief Officer of the London Fire Brigade. Major F. W. Jackson has been promoted to Deputy Chief Officer.

INFESTATION OF STORED GRAIN.—The Stored Products Laboratory of the Imperial College of Science and Technology is to carry out a survey in connection with the destruction of stored grain and grain products by insects. The losses caused by such destruction is estimated at half a million pounds annually, and a scientific survey is to be made at once during the period of seasonal activity of the insects.

WATER POWER IN ITALY.—A hydro-electric power station is to be built in Italy in the Abruzzi, on the Vomano Mountain, which it is said will ultimately be the most powerful station of its kind in Europe. Reports state that three stations and an artificial lake of 500 million cubic metres capacity are to be built. Work is already in progress on a chain of six hydro-electric stations in the Isonzo Valley, and they have been designed for an output of 500 million kilowatt-hours.

A SOUTH WALES COAL MINE DEVELOPMENT.—Work is shortly to begin on the development of a large area of industrial gas coal under the Burry Estuary in the Penclawdd district. According to *Iron and Coal Trades' Review*, a point to the west of Penclawdd has been selected for a drive into the Penlan seam, last worked in the vicinity when a colliery on the eastern side was abandoned in 1893. This colliery worked up to a geological fault in the west, which was not crossed. Leases have been obtained for this purpose. Nearby, the Penlan Colliery, which closed down during 1908, has already worked the Big Vein extensively to a depth of 650 yards. The new company intends to explore the Penlan seam overlying the Big Vein.

CANADIAN PULP AND PAPER INDUSTRY.—Last year Canada produced more than 74 per cent. of the newsprint production of the North American Continent, and 41 per cent. of the world production in 1937, the tonnage reaching 3,650,000 tons. The industry owes its development to the existence in Canada of extensive resources of the various pulpwood species in conjunction with abundant water powers to supply the enormous power demands for the conversion of the timber into paper. The fact that a mechanical power installation of approximately 100 H.P. is required per ton of daily output of newsprint, and, in addition, about an equivalent amount of hydro-electricity is at present being utilised for the production of process steam, shows the advantage of low-priced water power to the industry. Approximately 95 per cent. of the power used by the industry is hydraulic or hydro-electric. The hydraulic turbine installation in Canadian mills totals 678,982 H.P.

CO-ORDINATION OF GAS SUPPLY.—In his paper on the co-ordination of gas supply, before the Royal Society of Arts recently, Colonel W. M. Carr said that powers are now being sought for carrying out a scheme for a gas network in this country. It was first proposed to develop the network in the markets available under the control of the United Kingdom Gas Corporation, Ltd. Other markets, near coke ovens, to which supplies of gas could be offered on an economic basis would also be dealt with in the first place. The promoters of the scheme intended to distribute only purified gas in the network. The scheme, said Colonel Carr, would not only permit the utilisation of surplus plant and avoid the capital expenditure for the provision of peak load plants, but would permit a supply of gas to industry on terms not practicable under present conditions. The potential undeveloped industrial load in the network area is estimated at 5000 million cubic feet per annum.

EXPLOSIONS IN COAL MINES.—In reply to a recent question in the House of Commons, the Secretary for Mines said that it was indicated by the available information that at forty-eight of the ninety-one collieries at which explosions involving loss of life occurred between the beginning of 1930 and the end of 1937, and in the district of the mine involved in the explosion, either strip packs were used or the wastes were not packed. Solid packing was practised in two of the districts involved. A number of the explosions occurred in board-and-pillar workings or narrow places, where the question of packing did not arise. Forty-five explosions took place at mines in which all the coal cutting or conveying machinery was electrically driven, fifteen at mines in which all such machinery was driven by compressed air, twelve at mines in which both electricity and compressed air were used for the purpose, and nineteen at mines in which neither was used. He went on to say that in many instances where coal cutting or conveying machinery was installed at the mine there was none at the place where the explosion occurred, and in a number of other instances where such machinery was installed at that place it was not in use at the time of the explosion.

DEATH OF MR. P. H. SYMONDS.—We regret to note the death of Mr. Percival Herbert Symonds on Monday, May 23rd. Mr. Symonds had been prominently connected with mechanical and electrical engineering for many years and at the time of his death he was special sales representative of the English Electric Company. He was educated at the Grammar School and the Brassey Institute, Hastings; Rutherford and Durham Colleges, Newcastle-on-Tyne; and the Technical College, Manchester. After serving his apprenticeship in the works of Upfield and Sons, general engineers, Hastings, he joined the staff of Swan, Hunter and Co., Ltd. In 1905 he joined the then British Westinghouse Company, Ltd., and in 1907 he left to enter the steam turbine department of Willans and Robinson, Ltd., Rugby, where he remained until 1910. He then became the turbine sales manager of the Brush Electrical Engineering Company. In 1913 he rejoined Willans and Robinson, and from 1920 to the date of his death he was with the English Electric Company, which was formed to take over Willans and Robinson, Ltd., and other companies. He was a member of the Institution of Mechanical Engineers and an associate member of the Institution of Electrical Engineers.

Air and Water.

AIR MAIL SERVICE TO NEW GUINEA.—On Monday, May 30th, a weekly air mail service from Sydney to the Mandated Territory of New Guinea was inaugurated.

A NEW SOVIET DREDGER ORDERED.—The Government of the U.S.S.R. has placed an order for a large self-propelled steam dredger with William Simons and Co., Ltd., of Renfrew.

ROYAL AERONAUTICAL SOCIETY.—At the Council meeting of the Royal Aeronautical Society held on May 24th, 1938, Mr. A. H. R. Fedden was elected President of the Society for the year 1938–39.

R.A.F. AERODROMES IN SCOTLAND.—A site has been purchased near Edzell, Angus, for development as a Royal Air Force landing ground. It is expected that this ground will later be developed as an operational aerodrome.

NEW SUEZ CANAL DIRECTOR.—It is announced that Colonel Sir Maurice Hankey has been nominated for appointment as a director of the Suez Canal from August 1st next in place of the late Sir J. T. Davies.

DEE NAVIGATION.—At the annual meeting of the Chester Port Sanitary Authority, Mr. J. W. Coppack said that the Government is considering the granting of a subsidy for further improvements for navigation in the river Dee.

THE "QUEEN MARY."—The Cunard-White Star liner "Queen Mary" has completed two years' service on the Atlantic route. In this period, eighty-six crossings, covering over 256,000 miles, have been made and more than 115,000 passengers carried.

SALVAGE AT SCAPA FLOW.—It is announced that Metal Industries, Ltd., is to begin work on the salvage of the scuttled German battle cruiser "Derfflinger" at Scapa Flow. This 36,700-ton ship is lying upside down with a list of about 20 deg. in over 25 fathoms of water.

IDLE TONNAGE.—At the meeting of the International Chamber of Commerce Mr. M. P. Hill pointed out that whilst world trade had recovered to about 27 per cent. above pre-war level and tonnage had declined, there was still an excess of supply over demand of some 15 per cent.

THE R.A.F. AND LORD NUFFIELD.—The Air Ministry has announced that in a recent interview with Sir Kingsley Wood, the Secretary of State for Air, Lord Nuffield had placed his services at the disposal of the Ministry in connection with the Royal Air Force expansion scheme. It is generally expected that Lord Nuffield will be particularly concerned with the production of air frames.

NEW SOVIET FLOATING DOCK.—A 2500-ton floating dock which has been built for the Government of the U.S.S.R. by Swan, Hunter and Wigham Richardson, Ltd., is now being towed to Murmansk by three Soviet tugs. Built in two sections, it is over 396ft. long and has a breadth of 86ft., with a clear width inside of the stages of 66ft. As a whole, the dock is capable of lifting 2500 metric tons, the largest section will lift 1550 metric tons, and the smaller 950 metric tons. It contains seven pontoons, four in the larger section and three in the smaller.

BIG NEW SWEDISH LINER.—The motor liner "Stockholm," being built for the Swedish American Line by the Italian company, Cantieri Riuniti dell Adriatico, was launched on Sunday, May 29th. The new ship is 625ft. long and has a gross tonnage of 28,000. Propelled by three single-acting, two-stroke, ten-cylinder engines aggregating about 22,000 I.H.P., she will have a speed of 19 knots. Accommodation for regular North Atlantic service will be 1350 passengers with a crew of about 600. On pleasure cruises the accommodation will be limited to 620 passengers.

PORT OF LONDON AUTHORITY APPOINTMENTS.—Following the announcement of the appointment of Mr. J. D. Ritchie as General Manager of the Port of London Authority as from September 30th next, the Port of London Authority announces the following consequential appointments:—Mr. R. Letch (at present Assistant Dock and Traffic Manager) to be Chief Assistant to the General Manager; Mr. E. H. Lennard (at present Stores Officer) to be Assistant Dock and Traffic Manager; and Mr. E. L. Stanley (at present Personal Assistant to the General Manager) to be Stores Officer. These appointments will take effect immediately.

LAUNCH OF "WAIMARAMA."—An 11,000-ton cargo liner, the "Waimarama," which is now being built at Belfast for the United Kingdom–New Zealand trade, was launched on Tuesday, May 31st. The vessel, which is being built by Harland and Wolff, Ltd., for the Shaw, Savill and Albion Company, Ltd., London, is specially designed for the carriage of dairy produce, meat, and fruit. There will also be accommodation for twelve passengers. The "Waimarama" will make her maiden voyage in September or October this year. She will have an average cruising speed of 15 knots and is scheduled to make the journey to New Zealand in approximately thirty days.

BRITISH AIRWAYS MOVE TO HESTON.—British Airways changed their base of operations from Croydon to Heston Airport on Sunday, May 29th. With this move of the company, which was the first British concern to fly night mail schedules and now operates more Continental mileage than any other British air line company, a great deal of Continental traffic will swing over from the South London airport of Croydon to the West London airport of Heston. British Airways was formed in October, 1935, by the amalgamation of five companies, which included Hillman's Airways, United Airways, and Spartan Airlines. Apart from the London–Paris and London-Brussels services of Hillman's Airways, the operations of these companies were confined to internal work, but almost immediately the scope of the new company increased and advanced in rapid strides to the position it holds to-day. In July last year the Government announced that the company had been selected for the operation of a South Atlantic service to South America. Survey flights on the first part of the route to Lisbon and West Africa will be undertaken this year, and four 250-mile-an-hour super Lockheeds have been bought for this purpose.

LINCOLN WORKS OF RUSTON AND HORNSBY, LIMITED

(*For description see page 618.*)

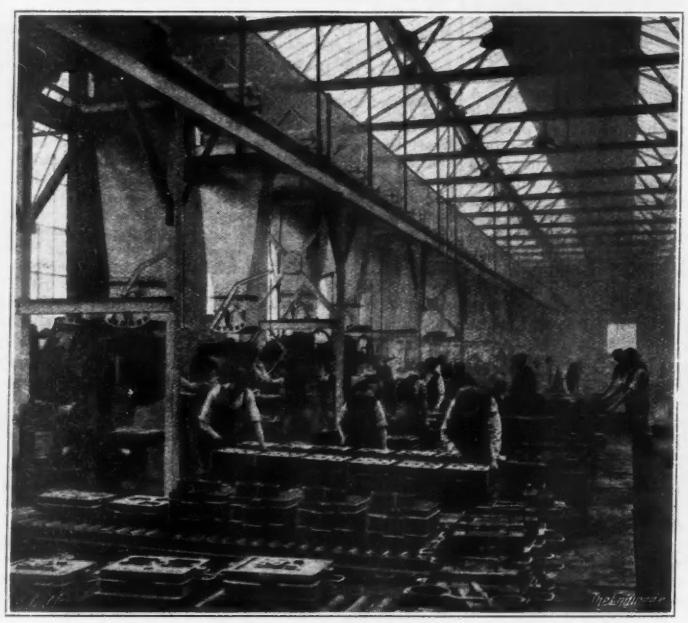


FIG. 7—LIGHT CORE-MAKING SHOP

FIG. 8—LIGHT CORE-DRYING STOVE

FIG. 9—HEAVY FOUNDRY

FIG. 10—MAIN FOUNDRY CUPOLAS

FIG. 11—MOULDING MACHINES IN MECHANISED FOUNDRY

FIG. 12—PLATE CONVEYOR AT CASTING STATION

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*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

BRITISH TRADE WITH FRANCE.

MACHINERY of all kinds is prominent at the Paris, Lyons, and Lille Fairs, but it is part of displays that cover every branch of national production. It is this mixed character of the Paris Fair, which opened in Paris last week and will close on Whit Monday, that gives to the machinery sections a varying importance, depending upon the economic and other conditions of the time. The extent of makers' participation is an indication of movements and changes that are taking place in industry. This year a notable feature is the much larger area in the machinery hall devoted to machine tools, notwithstanding the abstention of the Chambre Syndicale of French machine tool makers, which continues to hold aloof from the Fair. One reason for this abstention is a desire to organise an independent international machine tool exhibition in Paris on a scale in keeping with the importance of the industry. The carrying out of the scheme is retarded by difficulties arising out of the situation of the industry itself. The construction of machine tools in France underwent its most active development at a time when foreign makers were already in possession of world markets, and were able to supply machines which French makers could not afford to build so long as they were restricted to a limited market at home. It is true that the situation has changed recently, and that, in consequence of armament activity, large quantities of machine tools have been exported to Great Britain and other countries, while the home demand has grown and is likely to increase with the efforts being made to modernise plants for an expanded production. At the same time, imports of machine tools, especially from Germany, have increased considerably, and French makers are endeavouring to meet that competition, so far as State requirements are concerned, by arranging for orders to be distributed over sufficiently long periods and under conditions that will enable them to build whatever machines may be wanted. The State is disposed to provide these facilities as far as possible, but there is the difficulty that special machines must find a wider market abroad if prices are to be competitive, and no monopoly of the home market can be secured by any class of manufacturers so long as users can lower production costs by employing foreign machines.

These reasons explain why German manufacturers and to a lesser extent Swiss and other foreign firms, excepting British whose abstention is almost complete, should have given more than usual importance to the machine tool section, and overshadow the French industry represented by relatively few makers. German firms are aware of the possibilities of trade in France, in view of that country's policy of industrial expansion, and the Fair offers them the only means of giving prominence to their machines. It is argued that the Fair can have little commercial value to British and French machine tool makers, who are perfectly organised and are in close touch with French customers, but this situation does not apply to manufacturers other than machine tool makers, and those manufacturers have little opportunity for presenting machines to French buyers except at the Fair. One reason for the abstention of British machine tool makers is declared to be their inability to guarantee dates for delivery acceptable to foreign customers, and there is, moreover, the added difficulty of being unable to quote competitive prices in an inflated French currency. The situation of German manufacturers is not comparable with that of the British, since the export trade from Germany is State-aided, and imports of machinery subjected to quotas from that country into France are much larger than are those from Great Britain. The quotas are based upon a reference year during which Germany supplied to France by far the larger quantity of machinery. In giving so much prominence to their machinery production, German manufacturers are assisted officially more with the idea of prestige than with the actual business results of a participation in the Fair. The value of prestige in foreign business cannot be overestimated, and it must be maintained if it is not to be lost beyond recovery. Foreign buyers soon forget those suppliers who believe that they can live on their past reputation. The foreign machines exhibited do not usually compete directly with the French productions, and apart from gear-cutting and grinding machines and automatic lathes, the sense of prestige is awakened by demonstrations that suggest a technical advance which may, in reality, be no more than a creditable invention of long ago. On another side, the heavy additional expenditure on public works in France should occasion a further need for all kinds of machinery for road-making, excavation, trenching, soil removal, and levelling. It seems possible to arrange enough space in the Parc des Expositions for as many exhibits of such machines as may be desired, but the number shown is limited, though fairly representative of French and foreign productions in this branch of industry. In high-duty excavating machinery the business is still largely in the hands of British and American firms, and German excavators are again being shown, but the French are steadily developing their own productions with heavier machines of larger capacity. They are able to do this with the progress being made in French compression-ignition oil engines, for which machinery makers were formerly dependent on foreign supplies. Each year sees an addition to the ranks of makers of road construction machinery. In the lighter machines the French are capable of supplying all that is needed. Nevertheless, the heaviest work can only be done efficiently by foreign machines, and British excavators appear to be employed at least as largely as any others. In a general way it is sought to encourage the use of French machines for work which is intended to alleviate unemployment but, after all, it is the contractor who is responsible for the selection of machines, and in his own interest and in that of his men he employs those which are the most suitable for the work in hand. This necessity for economy and efficiency is applicable to other classes of machines, and particularly to oil engines, which are represented by English firms who fully uphold British reputation in this branch of engineering production.

The French are making progress in all manufactures which they formerly neglected, but if British makers maintain their lead, as they appear to be doing, there is no reason why they should not improve their business in France at a time when so much is being done to promote trade recovery. It would be regrettable if future business were compromised because British makers are handicapped by present difficulties; French manufacturers have their own troubles in the high cost of production. Between France and Great Britain there is every prospect of wider facilities being offered for mutual trade exchanges in the early future, but it is necessary, in the interests of foreign trade generally, that measures should be taken to prevent any decline of British industrial prestige abroad, which is threatened more particularly by the activity of foreign manufacturers with the incentive of subsidised exports. The practice of subsidising export trade, by direct or indirect means, is gaining ground on the Continent, and must be taken seriously into account by British manufacturers.

Profits and Wages.

WE recall a conversation not long since with the managing director of a marine engine building firm of the highest standing. During the depression there arose a chance of securing an order at cost price, if the men would agree to certain terms. The position was put before them, but they could not be convinced that the firm was not in a position to pay them at the ordinary rates and yet make an ample profit. The delegates were then asked what they thought the usual profits of such a works were, and they replied thirty-three per cent.! We asked the director how they could have reached such an astonishing figure, and he replied that he believed they estimated profits on the same scale as the bonus and piece time pay they were able to earn. Since the men took as a rule about one-third more in wages than the standard wage rate, they had reached the conclusion that the firm's profits were estimated on the same basis. It was found impossible to convince them that there was no such comfortable margin; they refused to accept the proposed conditions, and the order was lost. Incredible as this mistaken idea sounds, it is supported by the opinion which, it would appear, holds amongst American workpeople. Thus we read that in an inquiry made at the gates of a factory in Chicago out of 518 men, only four thought they got in wages as much as 10 c. out of each dollar of income produced by the company, and 378 were firmly convinced that they got less than 5 c. Whilst such hopelessly mistaken views prevail, it is scarcely surprising that the tub-thumper has no difficulty in persuading his impressionable audiences that the employer is "grinding the faces of the poor."

Some time ago an inquiry was conducted in the United States under Government organisation into the national income of the country between the years 1929 and 1935. From an analysis of the report of this inquiry, it appears that of all the "income produced and paid out" by American manufacturers, about 84 per cent. is expended on labour. We have not got a copy of the report, issued by the Department of Commerce, U.S.A., before us—even in its country of origin it seems to have been overlooked—and we are therefore unable to give the details of the manner in which the estimate has been reached, but *a priori* we see no reason to doubt that it not only represents the true facts for America, but for any manufacturing country. Great as the difference between that figure and the trifling estimate of the Chicago men is, we have little doubt that even if the true position were brought home to them, workmen would still protest that the margin of 16 per cent. was excessive, and it would be necessary to explain to them all the charges which gross profits have to bear before a margin is left for the shareholders. Even then, owing to the misleading nature of dividends on capital, they might fail to appreciate the real facts. Consider the case of a firm which, starting with a small capital, continually increases its resources by extensions of plant, &c., paid for out of revenue. The dividends on the nominal capital appear to be abnormally high, and it is not at once obvious that, in fact, each shareholder has invested more money in the concern than his share certificates indicate. Every penny of profits may be regarded as the property of the shareholders, and such proportion of it as goes back into the business for extensions, the purchase of tools, and so on, is really reinvested money increasing the actual capital. Hence high nominal dividends on original capital may give quite a wrong impression. Furthermore, the normal workman rarely or never looks beyond the firm for which he works, and often not beyond one or two individuals in the firm. He forgets that it is the purchaser who pays him; the employer is only an intermediary between him

and the market. If the employer is a very successful man, it is because he gives the purchasers just what they want, and they reward him accordingly. There is no material difference in that respect between a manufacturer and a film star or a centre forward. They are all paid highly because people want what they are capable of providing. Where individuals draw enormous incomes from manufacture it is safe to assume, in a large percentage of cases, that the world has found them quite worth what it pays them. If it did not, it would soon cease to purchase their products. But even when the net profit paid to shareholders or individuals is high, it will be found that labour still receives the lion's share of all the moneys passing through the company's books. The official estimate of 84 per cent. reached by the American Government investigation is probably equally true for this country.

On various occasions it has been suggested that a clear statement of the accounts of engineering firms should be posted for the information of employees. In a few cases, we believe that that is done as a regular practice, and in some we know the plan has been followed in particular instances. But, as a whole, it has not been favoured. There are manifest difficulties in explaining a balance sheet and a profit and loss account to untrained minds, and a doubt whether the average workman would accept such statements is not unreasonable. Perhaps as education extends, and if it is properly directed, the practice of laying the accounts before the employees may be found practicable and desirable. It is worth observing that that course is again being considered in the United States. But whether or not an acceptable means of informing workpeople accurately concerning the economics of manufacture are found, it is certainly desirable in the highest degree that such misapprehensions as those we have alluded to should be removed. Fortunately, a great deal of good work is done at the occasional conferences of the A.E.U. with the employers' federations, but there is no certainty that the effects filter through to the members of the unions, and it is unfortunately a fact, in this country as in America, that the soap-box orator induces workpeople to believe statements which are more often than not based on incomplete or inaccurate analyses. How far it is in the ability of employers to check that kind of evil, we are not in a position to say, but we should be glad to know if any firm has ever arranged one or two popular lectures a year for its workmen on industrial economics, and, if so, what result was achieved.

The Incorporated Municipal Electrical Association.

No. II.

(*Continued from page 597, May 27th.*)

STREET LIGHTING.

THE automatic control of street lighting was the subject of the first paper placed before the Convention on Tuesday afternoon, May 24th. The authors—Messrs. E. E. Hoadley and H. Purslove Baker, of Maidstone—described what they have done in devising a system which overcomes the difficulties of hand switching of individual lamps or small groups of lamps, time switches and control by light-sensitive cells. They have adopted a system of central control by superimposed signals from the generating station, known as "ripple control." The system is used to the largest extent in France, although it is also in use in the United States, Germany, and Belgium. Maidstone was the first installation in Great Britain, and a number of municipal authorities are contemplating similar installations. Practically the whole of the street electric lamps in Maidstone—1369 in number—are now switched on and off by means of ripple actuated relays, the ripple being sent out from the central station over the whole system. This number of lamps will shortly be increased to 1600. After eight months' experience it is asserted that the operation has been ideal. Not one single second's trouble has been experienced, either with the plant in the generating station or with any of the 570 relay-operated switches, and it is emphasised that the Maidstone installation is the first ever to be used on both A.C. and a D.C. network. It is claimed from this experience that, apart from the other advantages, such as the control of off-peak load, use in national emergency for signalling, and other purposes, such a system gives all the advantages of a separate mains system for street lighting at a very much lower cost, and ensures that the whole of the street lighting over a considerable area can be switched either on or off in eighty seconds from first pushing the button.

The principle of the system is the injection of a superimposed signal into the distribution system from a transmitter in the generating station or bulk supply station, thereby avoiding all control apparatus in sub-stations. The frequencies of the alternating-current signal actually chosen vary from about 300 to about 800 cycles, and within that range it is possible to provide six to twelve different signal frequencies, one for each operation, such as street lights on, street lights off, all-night lamps off, air-raid precautions alarms, and so on. The effect on the consumers' apparatus is inappreciable as the ripple cancels itself out many times in the course of a load cycle, and it only affects the apparatus designed to receive it, *i.e.*, the receiving relays. The three-phase ripple is generated in a special alternator, and is injected into the outgoing feeders by means of three-phase current transformers whose high-tension windings are in series with the feeders themselves. The various signal frequencies are obtained by corresponding variations in the shaft speed of the machines, either by a variable-speed D.C. motor (the method favoured on the Continent) or by a synchronous motor and a mechanical change-speed gear-box (the method employed in this country). The transmission equipment consists of the ripple generator, emission transformers and condensers, and there is also the contacting gear and main control panel, with the reception relays on the system. To transmit the signal the operator has only to turn a key in a switch on the control panel corresponding to the frequency he wishes to transmit, and then press a button. The panel of contacting gear, in addition to starting the generator set, automatically controls the voltage of the generator, the capacities of the various condensers, and the whole sequence of operations.

There was a long and critical discussion on the paper, in which it was made quite clear that there are many advocates of the earth return and the D.C. bias methods of controlling street lighting. It was stated, for instance, that there are one hundred installations involving 10,000 relays working on the earth return system, and that the responsible engineers are increasing the size of their installations rather than otherwise. Instances were also mentioned of more or less experimental installations using the D.C. bias method, so far with full satisfaction, and apart from the technical aspects of the various systems, it was urged that the whole thing boils down to one of cost, in which is involved the question of whether a centrally controlled system or a locally controlled system should be adopted. The system advocated in the paper is one of central control, but there was strong advocacy of starting with a local control, and gradually building up to central control in view of the impossibility in most cases of adopting a new system in its entirety at one stroke.

A number of criticisms of the technical principles of the ripple signal system installed at Maidstone, and suggestions were made for injecting a ripple in a cheaper manner, one of the essentials being a more sensitive relay. On this point, the authors replied that a highly sensitive relay of the necessary robustness for this purpose was not easy to devise, and that up to the present there did not seem any prospect of obtaining it.

The general reply of the authors was that such a large amount of work has been done on the ripple signal system that it cannot be minimised, and that already something like 250,000 lamp-posts in this country and elsewhere are controlled by this system. At the same time they did not suggest that there would be a sudden change-over to the particular system, and admitted that for a long time there would be room for other systems, even including time switches, a representative of which said that although in the past when new methods of control had been brought forward the makers of time switches had felt badly shaken, they no longer had this feeling, because experience had shown that time switches were still holding their own.

Mr. Hoadley, however, wound up by saying that the discussion had not convinced him that he had taken the wrong step, and he was still satisfied that the savings he would make in many directions would cover the capital charges and maintenance costs.

POWER STATION PRACTICE.

The one paper on the heavy engineering side of the industry was entitled "Present-day Trends in Power Station Practice," and was presented on Wednesday morning, May 25th, the authors being Mr. H. C. Lamb (Chief Electrical Engineer, Manchester), and Mr. K. Baumann.

This paper is based to a large extent on observations which the authors made in America in 1936, and, in particular, during visits to power stations arranged in connection with the World Power Conference. Eight of the principal power stations were inspected, but in reporting their observations, the authors give an added interest by describing at the same time British practice, the progress made here, and the general trend of development in both countries.

It is pointed out that the total units generated in America in 1936 amounted to 113,373 millions, in contrast to 21,650 millions in this country. These figures represent an American increase since 1921 of 177 per cent., against 345 per cent. in Great Britain. On the other hand, the actual increase in units generated per head of population has been greater in America than here, the increase during the fifteen-year period being from 380 to 850 in America as against 114 to 480 in Great Britain. The average coal consumption per unit generated has for many years been lower in America than here, but the difference has decreased considerably since 1921, and in 1936 was only 2 per cent.

Commenting on some features of power station development, the authors say that reheating is again being revived but add that in new power stations careful examination should be made to ascertain whether, under the particular conditions of load factor, cost of coal, &c., reheating would be justified. In view of the relatively small economy possible, *i.e.*, about 5 per cent., the authors suggest that reheating would ordinarily only be justified where very high pressures were adopted, and where excessive wetness of the steam, in the low-pressure end of the turbine, would result in wear of the blades. In view of the present tendency towards higher pressures and temperatures, it is suggested it may be advisable to consider the improvements still obtainable from reheating.

During the period of industrial depression in America it has been very difficult, and, in many cases, impossible for American supply authorities to take advantage of the latest technical developments and the higher thermal efficiencies attainable with higher steam conditions. New stations could not be built to replace old stations, as the increase in generation costs due to the new capital charges would more than offset the fuel saving. In these circumstances, increased attention has been given to the form of plant extension which consists of new high-pressure, high-temperature boilers, in conjunction with high-pressure primary turbines exhausting into existing turbines working at normal pressures of 200 lb. or 300 lb. per square inch. It is recognised that the principle, designated "super-position," is not new. Several plants working on this principle have been in operation in America for a considerable time, and also at Billingham in this country, and in Russia, but the term "super-position," according to the American definition, is only applicable where extra high-pressure plant is superposed on existing plant in order to postpone the obsolescence of the latter without introducing reheating of the steam. The conditions, however, are more favourable in America than in Great Britain, because for 60 cycles a higher turbine speed (*i.e.*, 3600 r.p.m.) can be used, whereas the highest speed for a non-geared set in this country is 3000 r.p.m. The capital cost of these turbines is consequently lower in the United States. The use of high-capacity boilers in America is also favourable to the introduction of superposed plants, as with large boilers the capital cost per kilowatt capacity is reduced. It is claimed that under favourable conditions, super-position can be installed at a cost of £16 to £18 per kilowatt of additional capacity, and the authors point out that this is about the same as that for a new plant extension consisting of condensing units. It is added that super-position is particularly favourable in stations where further cooling water facilities for condensing are difficult to obtain and where the existing plant operates at comparatively low pressures (300 lb. per square inch or lower), provided that the low-pressure plant has still considerable life. It may also be possible in certain conditions to increase the plant capacity to a greater extent by super-position than by extensions with straight condensing sets, and in some cases without addition to the existing building. In view of the high cost of building in America, this may be an important factor. However, the authors emphasise that in estimating the advantages to be obtained by super-position, the load conditions and the effect of transferring the load from other plant to the reconstructed plant must be examined. In general, it is said that super-position does not pay unless additional plant is required and unless the load factor is very high.

As regards boiler developments, the authors comment on the important and drastic changes which have been made during the last few years, and remark that the movement towards higher pressures and greater capacities may demand even more changes in the future. In America, fully 80 per cent. of the large boilers installed in recent years (*i.e.*, for capacities above 300,000 lb. per hour)

are provided with pulverised fuel firing. Higher pressures, too, have brought with them problems in water circulation, and two types of forced circulation boiler which have recently come into prominence are the Loeffler and the La Mont. Two Loeffler boilers are installed at the Brimsdown power station of the North Metropolitan Electric Power Supply Company, and a La Mont is being installed in the Deptford West station of the London Power Company. American practice, however, favours natural circulation even for the highest pressures, and little or no progress has been made in America in the use of forced circulation.

A very important feature in the design of modern boilers is the large combustion chamber now generally provided, with a consequent decreased "heat-release," *i.e.*, the B.Th.U.'s released per cubic foot of combustion chamber volume per hour. There is also a strong tendency to-day to reduce the number of boilers per turbo-generator, as this allows of a simple arrangement of pipe work. The authors think it might even be that this tendency will go further in the future, and, for base load stations at any rate, the arrangement favoured may be one boiler to supply the whole of the steam for one turbine, as at Port Washington.

The latest type of slag-tap furnace in America consists of two chambers. The initial combustion zone is restricted to the primary chamber designed to maintain a high temperature to facilitate slag tapping, and a secondary chamber is introduced to cool the gases to a temperature calculated to prevent fouling of the convection tubes.

On the question of boiler-feed water treatment, it is remarked that sodium aluminate has been gaining in favour as an aid in both softening and conditioning, since it promotes flocculation of suspended impurities such as calcium phosphate, the cause of the well-known "phosphate haze," often seen in boiler waters which tend to prime. It is suggested that the future will probably see greater use of welded and forged drums, which will very largely do away with the danger of embrittlement from substances in the boiler water.

Making the comment that corrosion troubles are now of diminishing consequence, as a result of de-aeration and conditioning of the feed water, the authors report an unusual experience with the 1300 lb. Port Washington boiler. A number of water screen tubes failed owing to very rapid corrosion, although the oxygen content in the water was only 0·003 c.c. per litre. The trouble seems to have been cured by reducing the alkalinity in the water and eliminating an oxygen reducing agent which had previously been used. This, it is pointed out, is new in boiler chemistry and suggests that alkali in the presence of certain substances which absorb oxygen, may corrode steel rapidly.

Special reference is made to the immense value to the electricity supply industry of the successful practical example of one solution of the problem of washing boiler flue gases carried out under the guidance of Sir Leonard Pearce at the Battersea station.

In connection with steam piping, the necessity for designing in order to take care of creep is pointed out and the increasing use of all-welded piping in America is noted. At Connor's Creek station an electrical instrument known as the Arconograph is used during welding to produce a graphical record showing the consistency of the operation. This has been considered as more satisfactory than X-ray examination. After the weld has been completed, it is stress relieved at a temperature of 1100 deg. to 1200 deg. Fah. by means of an electric induction heater for one hour per inch of thickness, and allowed to cool slowly under control of the heater to 600 deg. Fah. Finally, all welded piping is subjected to a hydraulic test. The practice of welding pipes is receiving close attention in this country by manufacturers, users, and insurance companies, and the authors have no doubt that considerable progress will be made during the next few years. At the Brimsdown station piping of chromium-molybdenum steel has been welded by the oxy-acetylene process in accordance with the practice in Loeffler boiler installations on the Continent.

As regards turbines, during the last ten years the tendency in turbine design in America has been dominated by the desire to obtain the maximum possible output from turbines running at 1800 r.p.m. To achieve this object, the peripheral speed of the last row of moving blades has been gradually raised, and is now about 1200 feet per second. The output reached with single-flow machines is 80,000 kW, and with double-flow machines 160,000 kW. As the result of the higher blade speeds, considerable difficulties have been experienced in America, through erosion of the blading in the low pressure end of the turbines, and the necessity for reducing wear has forced manufacturers to provide blades protected by means of shields in almost all large turbines, a practice which is also increasing in this country.

In condensers American practice still continues to favour the single-flow arrangement, primarily from the standpoint of simplification of the circulating water piping and lay-out. American practice, too, favours the expanding of condenser tubes at both ends. A number of engineers, however, prefer bowing of the tubes to compensate for expansion. In this country ferrules at both ends are still specified, but expanding and bell-mouthing of the tubes on the inlet side is becoming more usual, as are special fittings which secure a tube from spinning, thus achieving the same effect as expanding. Expanding at both ends has not been looked upon favourably.

Speaking of auxiliary drives, an interesting development at the Brimsdown station in connection with the new extra high-pressure plant is mentioned. Here the fans, stokers, and feed pumps—the latter of the reciprocating type—are all D.C. driven from Ward-Leonard controlled motors and generators, the latter being direct coupled to the main condensing unit. The D.C. voltage automatically determines the correct relative output of each auxiliary. The remaining station auxiliaries are driven partly by alternating-current motors supplied from the house service set, coupled direct to the primary turbine, and are capable of maintaining sufficient output to keep the main plant in full operation, even though the frequency of the supply to auxiliaries should fall to 75 per cent. of normal.

The rating of generators running at 3000 r.p.m. has been progressively increased in America during recent years from 30,000 kW to 60,000 kW. This has been rendered possible by improved materials for rotor forgings, improved rotor and stator cooling, and by the use of hydrogen instead of air as the cooling medium in a closed circuit. The introduction of hydrogen cooling, however, has not yet affected the position in this country as units of large size operating at 3000 r.p.m. are obtainable with normal air cooling. It is suggested, however, that the use of hydrogen may assist in the development of generation at still higher voltages, as less corona is formed in a hydrogen atmosphere.

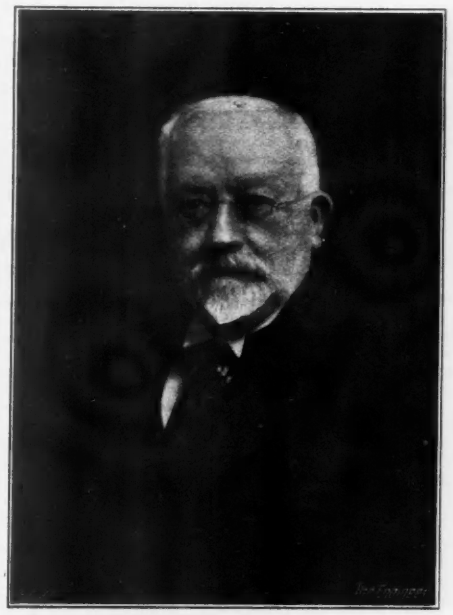
In connection with switchgear, emphasis is laid on the influence of high-power switchgear testing stations on design and performance, and to the fact that metal enclosure of switching apparatus for high voltage and heavy duty was primarily a British development. Its popularity, however, is greatest in this country, although it is attracting considerable attention now in other countries.

(To be continued.)

Obituary.

WILLIAM STROUD.

ON Friday, May 27th, the death took place, at Torquay, of Dr. William Stroud, Emeritus Professor of Physics in the University of Leeds, and one of the founders and the chairman of Barr and Stroud, Ltd., scientific instrument makers, of Anniesland, Glasgow. Although he was seventy-eight years of age, Dr. Stroud continued to take up to the last the keenest interest in scientific problems connected with the work of his firm, and in recent years it was his practice to spend several months during the summer at the Anniesland works.



DR. WILLIAM STROUD

He was born at Bristol on February 2nd, 1860, and received his education at the Bristol Grammar School and Balliol College, Oxford, where he obtained first class in the honour schools of mathematics and natural science, and graduated M.A. Later he continued his scientific studies at the Universities of Heidelburg and Würtzburg. On his return to England he obtained his D.Sc. in Physics at the University of London.

In June, 1885, Dr. Stroud was appointed to the Professorship of Physics at the Yorkshire College of Science, Leeds. It was in August, 1885, that he met for the first time Professor Archibald Barr, who a year earlier had been appointed Professor of Engineering at the same College, and a friendship was started which lasted for forty-six years until the death of Professor Barr in August, 1931. That friendship led to the founding of the firm which holds to-day a leading world position among the makers of scientific instruments for naval and military uses. His first work with Dr. Barr was, he records, in a little pamphlet issued in 1935, connected with the illustration of lectures, for which he designed a magic lantern suitable for the exhibition of very small apparatus which could be magnified on a screen. Together with Dr. Barr, he devised an apparatus for enabling lantern slides to be produced with great facility from any illustration in a book. "Those times were," he says, "very curious and science was in a state of frozen immobility. Almost the only physics then known were the physics of brass and glass. Mechanically propelled vehicles had a maximum speed of 3 miles per hour, and were compelled by law to be preceded by a man carrying a red flag. Aviation had been proved impossible by Lord Kelvin and motor cars were unknown. In the world of pure science X-rays were unknown and radium had not been discovered. Nothing was known about argon and the other rare gases of the atmosphere, while electrons, isotopes, quanta, and heavy hydrogen had not been heard of, and wireless was in the future. The redeeming feature, says Dr. Stroud in his early reminiscences, was that the income tax was only 6d. in the £ and death duties had not been imposed."

In 1888 the two inventors were on the point of starting research work on the numerical value of the mechanical equivalent of heat and apparatus for these experiments was being devised, when they chanced to see an advertisement by the War Office for a range-finder for the infantry, preferably a single-observer instrument with an accuracy of 4 per cent. at 1000 yards. In less than a month an instrument had been designed and was entered for the competition. It was delivered in December and official trials were carried out with the new rangefinder and certain two-observer instruments at Aldershot the following year. Although the Barr and Stroud rangefinder was not considered suitable for immediate adoption in His Majesty's service, the essential features of the design of the modern rangefinder were laid down, and work was continued on the design of two-observer instruments, which formed the subject of a paper read before the British Association at Leeds. In 1891 the Admiralty invited Dr. Stroud and Dr. Barr to submit a single-observer instrument for trial at a competition on board H.M.S. "Arethusa." Those tests were emphatically favourable. In order to defray the cost of this instrument Dr. Stroud undertook popular lecturing in the towns and villages around Leeds. Dr. Barr had removed to Glasgow University in 1890 and remained in touch with Dr. Stroud, making many parts of the rangefinder with his own hands and adjusting them from a platform which he constructed on the roof of his house. With the first Admiralty order for six rangefinders manufacture was begun, and James White, a Glasgow instrument maker, constructed the mechanical parts, according to Professor Barr's designs, while the optical parts were supplied by a London firm and were cemented together in Dr. Barr's study. In 1895 a workshop for assembling rangefinders was established in Byres-road, Glasgow, and as the business grew other premises were occupied in Ashton Lane. As the orders still increased the first portion of the present factory was built at Anniesland in 1904, which provided work for about 100 men. By 1914 the business was employing close upon 1000 men and rangefinders were being supplied to the British Government and to practically all important foreign Powers. During the war the works were greatly extended, and accommodation was found for some 2000 workers.

Dr. Stroud, it may be said, was a theoretical physicist of outstanding ability, a gift which he happily combined with a real knowledge of engineering design, and an ability for invention combined with a sound business knowledge. He won a wide circle of friends, both in Glasgow and in the South of England, where his health obliged him to live in recent years, and his death will be felt as a keen loss by his friends and business colleagues, and by the many military and naval officers from all parts of the world who knew him.

JAMES HOWDEN HUME.

COMBUSTION engineering has suffered a loss by the death in London in a nursing home on Tuesday, May 24th, of Mr. James Howden Hume, who, for the last twenty-five years, was the chairman of James Howden and Co., Ltd., of 196, Scotland-street, Glasgow, and Caxton House, Westminster. Mr. Hume, who was seventy-three years of age, lived for the past eight years in London, but he kept in closest touch with the many business, professional, and other interests which bound him to Scotland. He was a Glasgow man by birth and received his education at the Glasgow High School, and the Royal Technical College, Glasgow. After leaving college he served his apprenticeship with James Howden and Co., a firm which was founded by his uncle, Mr.

James Howden, in 1854. His ability was soon recognised, and he was appointed chief draughtsman and later general manager, before becoming a partner in the firm in 1900. Three years later, on the death of Mr. James Howden, he was elected the chairman of the firm, which had then become a private limited company, and that position he continued to hold with distinction until his death.

During his long career he did much to extend and develop the Howden system of forced draught, which is so widely used in connection with marine boilers. In recent years he took a leading part in the newer developments in air preheating and automatic boiler control, which have been successfully applied in modern power station and marine practice. He also occupied himself with the more recent trend of practice in gas-cleaning plants, both in connection with power station and industrial plants and at sea. In conjunction with Mr. John Johnson, he designed the Howden-Johnson marine boiler, which is being increasingly used both in this and other countries for the smaller merchant ships. He took a keen interest in the work of scientific institutions, and was a member of the Institution of Naval Architects, a Past-President of the Institution of Engineers and Shipbuilders in Scotland, and a member of the Institute of Marine Engineers. In Glasgow he was a Burgess and Justice of the Peace, and took an active part in the business of the Trades House and was a Deacon of the Incorporation of Hammermen. He was interested in art, and for some years was President of the Royal Glasgow Institute of Fine Arts. A keen Clyde yachtsman, he was the owner of several well-known yachts which he raced on the Clyde and in English waters. After he came South he became a Freeman of the City of London, and a Liveryman of the Worshipful Company of Shipwrights. His death will be regretted by a wide circle of personal and business friends.

J. W. MELLOR.

MANY of our readers will learn with deep regret of the death on Tuesday, May 24th, of Dr. J. W. Mellor, a ceramic chemist and physicist, who, for many years, was Principal of the North Staffordshire Technical College, and Director of the British Refractories Association. Dr. Mellor, who was sixty-seven years of age, died at his Putney home, and by his own wish his friends were not informed of his death until after his cremation at Golders Green on Friday, May 27th. He was born at Huddersfield and was educated at Dunedin and at Manchester. He obtained his D.Sc. degree in Science at the University of Manchester, and was appointed to the staff of the High School at Newcastle-under-Lyme. His next appointment was to the North Staffordshire Technical College, where he made a name for himself as Principal of the School of Pottery, a position from which he retired four years ago. For many years he held the position of Director of the British Refractories Research Association, from which he retired on account of ill health about a year ago. In our issue of December 14th, 1934, we gave an illustrated account of the Mellor Refractories Research Laboratories at Shelton, Stoke-on-Trent, which owed much to his organising ability, and his capacity as a teacher and a trainer of research workers. Over a long period Dr. Mellor was the Honorary Secretary of the Ceramic Society, and in connection with the work of the Society he travelled widely in the pottery centres of America, the Continent, and Scandinavia, and other countries. He was elected a Fellow of the Royal Society in recognition of his contribution to chemistry by his sixteen-volume work, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry." At the Coronation, his services to science and the ceramic industry were fittingly rewarded by the conferring upon him of the C.B.E. in the Coronation Honours.

BOOKS RECEIVED.

Foundry Sands. By T. R. Walker, M.A. London: Charles Griffin and Co., Ltd., 42, Drury-lane, W.C.2. Price 4s. net.

Gas Analysis. By A. McCulloch, M.Sc. London: H. F. and G. Witherby, Ltd., 326, High Holborn, W.C.1. Price 7s. 6d. net.

Modern Furnace Technology. By H. Etherington, B.Sc. London: Charles Griffin and Co., Ltd., 42, Drury-lane, W.C.2. Price 30s. net.

Metal Airplane Structures. By Major Flavius E. Loudy. London: Constable and Co., Ltd., 10, Orange-street, W.C.2. Price 24s. net.

Jacob Mayer: Der Erfinder des Stahlformgusses. By W. Bertram. Berlin: V.D.I. Verlag G.m.b.H., Herman Goeringstrasse, Germany.

The Principles of Motor Fuel Preparation and Application. Volume 1. Second edition. By A. W. Nash, M.Sc., and D. A. Howes, D.Sc. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 36s. net.

Directory of Paper Makers, 1938. London: Marchant, Singer and Co., 15, Nicholas-lane, E.C.4. Price 5s. 6d. net.

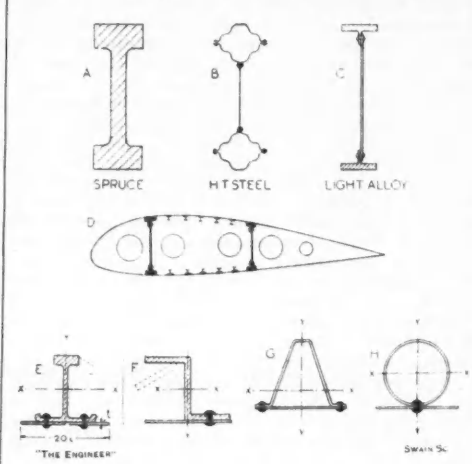
Fish Passes in Connection with Obstructions in Salmon Rivers. Being the Buckland Lectures for 1937. By T. E. Pryce-Tennant, M.B. London: Edward Arnold and Co., 41, Maddox-street, W.1. Price 3s. 6d. net.

Materials of Aircraft Construction*

By H. J. GOUGH, D.Sc., M. I. Mech. E., F.R.S.

DEVELOPMENT OF ALL-METAL AIRCRAFT IN LIGHT ALLOY.

THE most remarkable changes that have taken place, during the last twenty-five years, in the air frame, although resulting chiefly from changing aeronautical requirements, have been greatly assisted by the improved materials of construction that have been made available; the design and materials aspects are so interwoven that for the present purpose they must be considered together. In designing the earlier types of aircraft the main requirement was the provision of the necessary area of wing and control surface supported on a structure adequate to carry merely the aerodynamic lift, whereas the modern structure has to combine a certain specified external form



A, B, C.—Development of wing spar sections.
D.—Typical wing section of monoplane.
E.—Stringer of very efficient form.
F.—Common, but poor, design of stringer.
G.—Asymmetrical design of stringer.
H.—Tubular stringer (R.A.E.).

FIG. 1

having a very smooth surface, with sufficient strength to resist aerobatic loading, *e.g.*, pull-out from a power dive together with sufficient stiffness to obviate aerodynamic instability (flutter, reversal of aileron control). For many years wood, covered by fabric, formed the principal material of construction and in many ways it was and still is a satisfactory material. Wood is easily worked and the strength characteristics of selected timber are generally very reliable; it is not subject to corrosion and in temperate climates shrinkage may not be an important factor; its low shear modulus, however, is a drawback in its use as a stressed covering. It was the shortage of high-grade timber at the end of the Great War that was largely responsible for the change to metal construction, where the development has been limited to the use of steel or light alloy for all main structural components. The Short "Silver Streak" is believed to be the first all-metal plane, including covering, produced in this country; constructed in 1919, it was exhibited publicly in 1920. The fuselage was of monocoque form built entirely of duralumin sheet with continuous angle frames and intercostal stringers of triangular section; the planes were also covered with duralumin sheet; the spars being round steel tubes and the ribs built up of duralumin angles on the lattice girder principle. The new "Empire" boat is a straight development from the "Silver Streak"; the fuselage construction of the latter possesses much historical interest, as the design of the purely monocoque structure has really undergone very little essential change during the intervening years, an important improvement being the tubular stiffeners very recently introduced by the Royal Aircraft Establishment. The same year, 1919, saw the first all-metal construction in steel produced in this country, the rear fuselage of which was also of monocoque construction; in this machine, however, the fuselage and wing coverings were not of metal.

The relative merits of steel and light alloys involve a consideration of the different forms of the desired structure. In a biplane one might prefer all-steel construction and it is doubtful whether there would be any advantage gained in weight or ease of fabrication by the use of light alloy; in fact, any such advantage would largely depend on the experience and production facilities of the constructor concerned. Careful design has made possible the use of thin high-tensile steel strip in which very high stresses may be developed, while steel spars and other structural members lend themselves very readily to mass production methods. Before leaving the aspects of primary strength and stiffness it may be recalled that in comparing beams of similar cross sections, having the same strength in bending, but made of two different materials, the ratio of the stiffnesses is $(E_2/E_1)\,(f_1/f_2)^{4/3}$, while that of the weights is $(w_2/w_1)\,(f_1/f_2)^{2/3}$, where E_1 and E_2, f_1 and f_2, w_1 and w_2 are the elasticities, strengths, and densities, respectively, of the two materials. Now, very roughly, E, f, and w are in the same ratio for all structural materials and hence, in similar forms of structure, the lighter material gives a lighter and stiffer structure. Thus it would have been a retrograde step to replace solid wooden spars by solid metal ones and the advantage of metal could only be realised by the use of very thin-walled construction. But such construction at once introduced the problem of secondary failure by instability under compression and shear at stresses much lower than the maximum the material itself can safely withstand. The liability to instability can be reduced by local stiffening or curvature of the plate; curvature is appropriate when the stress is compressive, but in shear special stiffening is necessary. To meet these needs a most intricate system of spar sections was developed,† and steel spars of this type enable full advantage to be taken of the intrinsic strength of the materials (45–50-ton steel strip was first used; later, as high as 75–85-ton alloy steels were developed); the problem of local instability has, however, never been entirely overcome and still receives much research attention. The evolution which has occurred through changes in the materials used for skeleton structures is illustrated by some of the details shown in Fig. 1. A shows a common form of spindled spruce spar of I section. The change over to the use of thin strip steel introduced some complicated designs of the general form shown in B; with this form it is necessary to maintain a curvature in the flange of not more than thirty thicknesses in order to ensure stability. The use of rolled sections in light alloy permitted a reversion to the plain I section, as shown in C.

The problem of the spar having thus been met to a satisfactory extent, the next stage was the abolition of fabric as a covering; in service it suffered from many disadvantages and its replacement by thin sheet metal was a logical development. But very thin sheet of the lightest metals available weighed considerably more than the fabric covering it replaced and hence it was necessary to make the sheet metal take part of the load. As a first step the cross bracing wires between the lattice points of the basic metal framework were omitted and the metal panels used to transmit the shear loads, but this was soon followed by also imposing some of the direct loading, tension or compression on the panels. Intrinsic lightness was still a paramount advantage, so that the light alloys began definitely to displace steel in skin-stressed structures. This change was greatly accelerated by the gradual supersession of the thin-winged biplane by the thick-winged monoplane, with the increase in wing loadings from

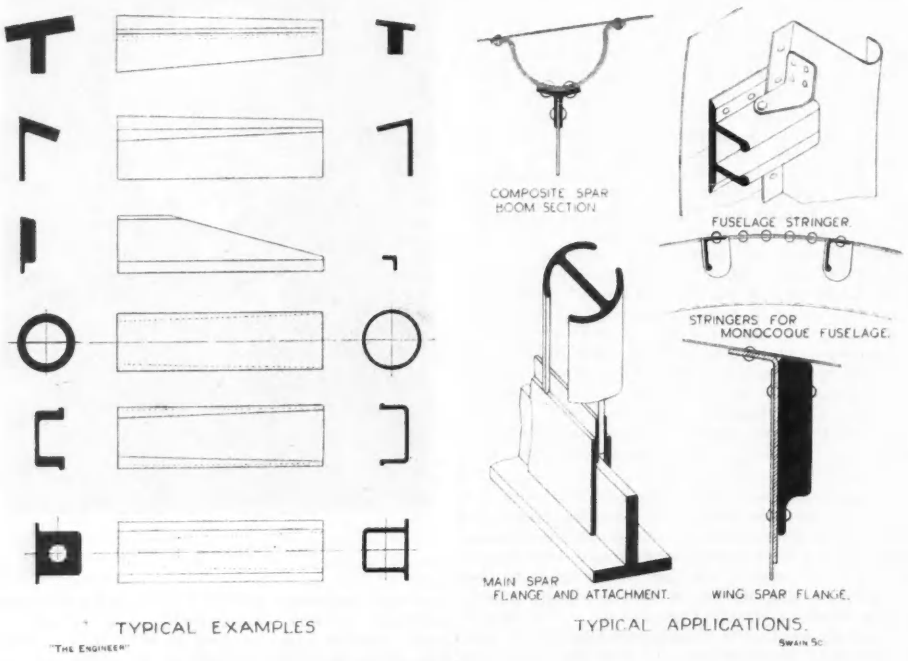


FIG. 2—*Extruded Sections of Aluminium Alloy.*

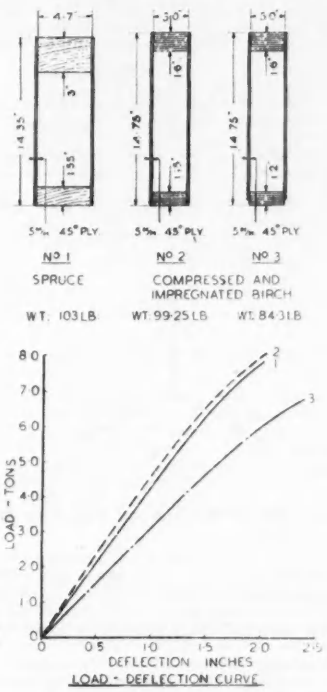
* Excerpts from the 1938 Wilbur Wright Memorial Lecture, the Royal Aeronautical Society, May 26th.

† "The Case for Metal Construction." J. D. North. *Flight*, October 26th, 1922.

15 lb. to 25–30 lb. per square foot. In a thin wing the torsion load has to be resisted mainly by differential bending of the front and back spars; in a thick wing it is possible to use a box form of construction to carry the torque. Nevertheless, since on the wing the bending load is much the most serious, the spar form of construction has much to recommend it and it remains in common use.

In present practice the metal covering of the fuselage is usually required to carry all the shear loads and part of the direct loads, whilst in the wings the sheet metal has often to transmit the shear load due to wing drag and may also be required to carry part or all of the shear due to torsion. Except in the multi-spar form of construction, however, it is seldom practicable to design a thin wing covering to carry any appreciable part of the direct loads.

The use of thin sheet metal in compression or in shear raises problems of stability similar to those that arose in connection with the built-up metal spar; but in this case, except perhaps by the use of corrugated sheet, the liability to fail by buckling cannot be entirely avoided. The majority of aircraft fuselages as now constructed fail, under test, by some form of instability in compression or shear, and the attention of the designer is largely directed to this type of failure. Now the stress which will cause buckling in the sheet is in general proportional to the elastic modulus of the material, to the square of its thickness, and inversely to the square of its minimum free width. Thus, if the superficial dimensions and the weight of the structure are fixed, the buckling stress is proportional to E/w^2, so that, assuming E to be roughly proportional to w for all materials, the lighter material is again the better. The buckling stress can also be increased by reducing the free width of the sheet metal panels, and this



SPAR	WEIGHT OF SPAR LB. (W)	FAILING LOAD TONS (P)	RELATIVE VALUES OF P/W
No 1	103	7·85	1·00
No 2	99·25	8·05	1·06
No 3	84·3	6·8	1·06

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FIG. 3—*Beam Tests of Wooden Box Spars.*

can be effected by sub-dividing the longeron members into a large number of stringers of fairly small cross section riveted to the metal sheet. At the same time, transverse rings are necessary both to maintain the form of the fuselage and to limit the free length of the stringers themselves, whilst certain special transverse frames may be required to transmit concentrated loads. In this type of reinforced pure monocoque the panels between stringers will normally buckle at a fairly low load, but failure in bending will not occur until one or more of the stringers also buckles in compression. Failure in torsion may be determined by tearing of the sheet or by collapse of the stringers or rings under the bending loads imposed by the tension diagonal stresses in the buckled sheet; but usually the strength in bending is the determining factor. It will thus be seen that in the monocoque fuselage no real advantage can be taken of any improvement of strength of the material above the buckling stress; what is required is a material having a higher E and/or a lower density. In the wing, on the other hand, whether a spar or a box form of construction is used, instability can usually be avoided, and in that case full advantage can be taken of any increase in the intrinsic strength of the material. It is important to notice, however, that a high strength may be rendered useless by a low 0·1 per cent. proof stress, since aircraft are usually required to carry three-quarters of the full factored load without permanent deformation. Ultimate strength is really the criterion for complete collapse and is normally more than $1\frac{1}{2}$ times the proof stress.

Returning to the fuselage it is necessary to remark that it is never possible to maintain the true monocoque form over the whole length. Openings have to be cut in the metal covering for cockpits, doors, windows, and bomb holes. The distributed loads that would otherwise be transmitted across these openings have then to be collected and carried round the edges. A similar problem concerns the provision that must sometimes be made for detachment of one portion of the aircraft from another (*e.g.*, rear end of fuselage from wing section); this again entails the collection of distributed load into one or two booms or longerons. These larger members are often of such section that instability is not in question, and in this case high strength is definitely advantageous. On the other hand, the load in such cases is usually purely tension or compression, so that increase of strength is worthless if it is accompanied by a comparable increase in density.

To sum up from the point of view of the structure, the chief need is for lighter materials, of which the intrinsic strength and stiffness may be less, provided neither is reduced in much greater ratio than the density. Increase of strength or increase in 0·1 per cent. proof stress, whichever is the determining factor, is worth having, providing the density is not increased; but even a small increase in density may more than offset the advantage of a slight increase in strength.

The important development of the production of extruded sections in light alloy has largely led to the replacement of rolled and drawn sections. Some typical examples and applications are reproduced in Fig. 2. At the wing root it may be found economical to introduce steel reinforcement in order to reduce the size of the attachment; the approximate identity of the ratio of proof stress to Young's modulus for steel and light alloy enables the two materials thus to be built up economically to form a composite structure. Fig. 1*d* shows the cross section of a typical monoplane wing in which use is made of extruded flanges of light alloy, riveted to a flat plate web and extruded stringers also of light alloy; the skin is of sheet or "clad" duralumin. In order to develop the highest stress in the construction the design of the stringers is of great importance. Their function is not only to stabilise the skin under compression and shear, but also to form part of a composite beam or strut of which about twenty thicknesses (the actual figure varies with skin thickness and stress) of the skin, together with the stringer flange to which it is secured, form one flange; this area should be balanced by an equal area forming the free flange. The web should be as thin as possible, consistent with the requisite shear strength. Fig. 1*e* shows a stringer designed to develop the highest stress in the skin. The area of the free flange is equal to the area of the lower flange, plus about twenty thicknesses of the skin; the stringer is therefore symmetrical about the major and minor axes: in order to avoid premature secondary failure under compression, as illustrated, the free flange should have the maximum M.I. about the minor axis consistent with stability of the free edge of the flange. Fig. 1*f* illustrates a very common, but poor, design of stringer, because it is unsymmetrical about the minor axis, and premature secondary failure is very likely to occur. Fig. 1*g* is also a very common type of rolled stringer; in this case the fault lies in the asymmetry about the major axis. Fig. 1*h* represents the tubular stringer designed by Gerard, of the Royal Aircraft Establishment, which is very easy to fabricate and is ideal for use with thin skin; a simple method of overcoming difficulties in riveting this form has been developed; in flying boats open stringers are still preferred for inspection reasons, but it is most probable that the advantages of the closed circular stringer will outweigh this consideration. Mention must also be made of the "Northrop" type of stiffener, for fuselage construction, in which the stiffener is a continuation of one of the overlapping skin plates, formed to a special shape.

Thus the light alloy all-metal aircraft of to-day represents, as far as the materials are concerned, a steady development of the sheet alloys for stressed skin construction, but the outstanding feature is the use of extruded sections. With even the present facilities available for their production, no difficulty is seen in producing aircraft designs of an all-up weight of 70–80 tons; such an aeroplane would be about 180ft. span and a length of about 140ft. It is unlikely that single extrusions could be produced for the spars of such an aeroplane, but it would be relatively simple to build up a spar of two or more extrusions. In this most interesting period of development the corrosion problem has been one of the most serious in connection with light alloy structures, but it has been largely solved by the introduction of the "clad" alloys, about 1930. Even with the "clad" materials it is still considered desirable to use the anodic process for its additional protection and, for marine work, a final greasing with a lanoline solution is strongly recommended, while a cellulose finish with two coats of undercoating and two finishing coats provides a good additional protection; it is general practice to anodise all light alloys and paint with a cellulose varnish.

An aspect of extreme importance, not previously mentioned, is the ease of manufacture, and metals which are easily manipulated offer marked advantages. For this reason those light alloys in which precipitation age-hardening takes place fairly quickly limits the time in which manipulation must be completed; whereas, in the improved alloys where precipitation takes place at some considerable temperature above atmospheric, this phase change can be delayed until produced by artificial heating conditions. The method of joining parts together is also most important. Skin-stressed construction is mostly riveted at the present time, and any method by which the plates can be brought to the machine, instead of riveting in place, offers an advantage. The same consideration will also apply to welded construction, for which there is undoubtedly a great future. In one type of construction now being developed and employed, 90 per cent. of the riveting is done away from the final construction. Stringers are attached to the flat sheets, the whole is offered up to the frame, riveted in position, and the stringer attachment completed.

CONSTRUCTION IN WOOD.

Probably the most interesting application of wooden construction to modern aircraft in this country is the de Havilland "Albatross" machine. The stabilised fuselage construction, consisting of two sheets of three plywood separated by a layer of Balsa wood, is an excellent example of the strength and stiffness that can be obtained by combining the excellent properties of three plywood with new design. Similarly, the unorthodox wing construction takes the fullest advantages of the materials in their application to stressed skin construction suitable for a monoplane. On this point it is stated that the wing is actually of thinner section than is usual in aircraft of this size, made possible by the "damping" nature of the materials used. The stability inherent in this wing construction is such that, under test, a stress nearly up to the ultimate compressive stress of the laminated spruce skin is developed before failure occurs. With such wooden construction the mounting of the engine can be carried out in a simple and effective manner; the mounting is of welded 30-ton $1\frac{1}{2}$ per cent. Mn steel tubes of round and square sections.

Much development work is in progress in the applications of reinforced timber for structural purposes; it will be recalled that this material consists essentially of laminations, with or without previous impregnation, and with or without fabric inserts, cemented together under pressure; the resulting specific gravity ranges from about 0·8 up to a limit of 1·4. These materials show to advantage under pure compression, the ultimate strengths being higher in proportion to specific gravity than that of aluminium and steel alloys; on proof stress they do not show up quite so well. Table I compares the average properties of a high-grade material with one of the best wrought aluminium alloys available.

TABLE I.—*General Comparison of a High-grade Reinforced Timber and a High-tensile Aluminium Alloy.*

	Reinforced* timber.	Al. alloy.
Specific gravity (S.G.)	1·4	2·8
0·1 per cent. proof stress (P.S.), tons per square inch	10·5	28
U.T.S., tons per square inch	20	33
Young's modulus (E), pounds per square inch $\times 10^{-6}$	4	10
Shear modulus (G), pounds per square inch $\times 10^{-6}$	0·25	4
Ratios: P.S./S.G.	7·5	10
U.T.S./S.G.	14·3	11·8
E./S.G.	2·9	3·6
G./S.G.	0·18	1·43

* These figures are conservative.

Thus, for purposes of monoplane wing construction, reinforced timber is well adapted to take bending loads either in the form of spar booms or skin covering, highly compressed timber being more suitable for the former. For the latter, on account of its greater bulk and inherent stability, timber of lower specific gravity is more suitable; if so used, the timber would serve as skin covering and shear bracing besides taking direct end load. But, as noted previously, the plywood skin, with separator, fulfils this purpose excellently. Reinforced timber shows up rather badly, when compared with metal, as regards the ratio of shear elasticity to specific gravity, and this is important as affecting the torsional stiffness of a monoplane wing; adequate torsional stiffness is required to prevent reversal of aileron control and various types of flutter. For this reason, also, the separated construction is such a valuable development. An interesting experimental development of the separated skin construction is the replacement of Balsa wood by vulcanised expanded rubber, the latter being very light and free from the liability to moisture absorption, mould and fungus attack, possessed by the Balsa wood and which makes necessary such careful sealing of joints and free surfaces; in an experimental wing section of this construction a very good strength-weight ratio has been obtained under test; failure did not occur until a stress of approximately 4 tons per square inch, reckoned only on the ply, was developed. Tests are also proceeding on the type of plywood which has an inner layer of duralumin; under very severe test conditions the adhesion of the wood to the metal has proved to be very satisfactory.

It may occur that in a wing section the depth of the spar is fixed, but any economy in width, without sacrifice in strength, is an advantage. Some experimental results, which reveal the advantages of the improved woods in this respect, are of interest. Three hollow box spars, each 16ft. in length, were made up; the cross-sectional dimensions being as shown in Fig. 3. The booms of one spar were of ordinary spruce, those of the others being of different types of impregnated and compressed laminated birch. Each spar was tested to destruction as a simply supported beam over a span of 14ft. 6in. with a centrally applied load. The load deflection curves obtained are reproduced in Fig. 3, while the inset table shows that marked economy of beam width and a small saving in spar weight can be obtained without any sacrifice in the total load-carrying capacity of the beam.

Laminated wooden construction lends itself very easily to strengthening by reinforcement at sections and ends subjected to heavy shearing or bearing forces; this can be achieved by fabric inserts introduced between the laminations. Where such loads are applied to timber through bolts, splitting is liable to occur; shearing tests of this type showed that laminated spruce, reinforced with fabric inserts, developed at failure a load $1\frac{1}{2}$ times greater than that of plain laminated material and $6\frac{1}{2}$ times greater than that of ordinary spruce; some typical applications of fabric reinforcement for structural purposes are shown in Fig. 4. Another method, used in practice, of reinforcing tailplane spar joints is by the use of plates of fabric-reinforced synthetic resin covered with plywood; these plates are glued on to the spar using a synthetic glue.

Many other experimental developments are taking place in the use of compressed impregnated woods for structural purposes. A spar may now be produced having selected properties of strength and density, varying along its length. Experimental spars of vacuum-impregnated and compressed wood, have been built up to 60ft. in length; such spars are not difficult to produce, neither is their actual cost of production uneconomic, but such production involves putting down, especially for the purpose, a considerable volume of rather expensive press plant. However, the further application of improved wooden construction to aircraft purposes appears to be most probable.

CONSTRUCTION IN PLASTIC MATERIALS.

The idea of aircraft structures, entirely made of moulded plastic construction, is most attractive and many references to the possibility occur both in technical literature and in fiction. The materials offer the advantages of extreme surface smoothness, stability, low water absorption, and ease of mass production. But although a plastic non-stressed fuselage covering actually appeared as early

as 1919, it is believed that no aeroplane made of plastic has yet been seen in flight, nor has one even been constructed. From the structural point of view, a plastic material to be successfully applied should have a strength-weight ratio substantially equal to that of steel, light alloy, or wood, based on tensile or compressive strength, whichever is the lower; also, since deflections are so important in aircraft structures, the further criterion of elastic modulus weight ratio is also involved; shear strength characteristics may often be dealt with by suitable design. But it is merely foolish to dismiss from consideration the potentialities of plastic construction, as is so often done, and in this 1938 Wilbur Wright Lecture—which aims at presenting the present-day position—the omission of a reference to some most interesting development work that is being steadily carried out would be regarded as a very regrettable omission. Through the much appreciated collaboration of the inventor concerned, the inclusion of such a reference has been made possible. About ten months ago a description‡ was published of a new type of wing primarily designed for construction in plastic materials. The prototype wing was built in wood and successfully emerged from its tests. At that time, no decision had been taken regarding the choice of plastic material to be utilised for the purpose. The choice has now fallen on a special material made from a cellulose fluff impregnated with a phenolic resin which can be moulded into a required form under a pressure of 2 tons per square inch at 150 deg. Cent.; passing reference to this material was made in the section on plastics in which the results of tests made on samples cut from moulded panels have been quoted. Comparing these data with those of the high-grade reinforced timber (U.T.S. 20 tons per square inch) and the best wrought aluminium alloy available (U.T.S. 33 tons per square inch), the comparison stated in Table II emerges.

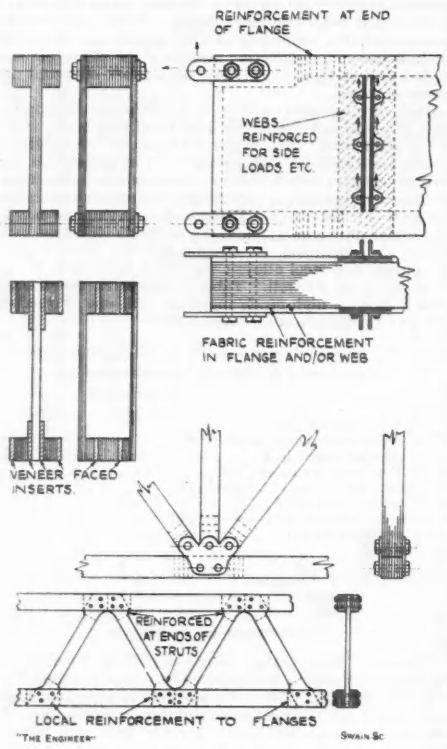
REINFORCEMENT AT END OF FLANGE
WEBS REINFORCED FOR SIDE LOADS ETC.
FABRIC REINFORCEMENT IN FLANGE AND/OR WEB
VENEER FACED INSERTS.
REINFORCED AT ENDS OF STRUTS
LOCAL REINFORCEMENT TO FLANGES
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FIG. 4—*Applications of Compressed Wood Locally Reinforced Against Shear.*

TABLE II.—*Specific Properties of Aluminium Alloy, Reinforced Timber and Plastic Material.*

Material.	P. stress. Sp. G.	Ratios. U.T.S. Sp. G.	E. Sp. G.
Al. alloy	10	11·8	3·6
Reinforced timber	7·5	14·3	2·9
Plastic material	4	6·4	1·4

Tests on struts and on experimental mouldings of skin and typical components have been made and the experiences gained from these have been incorporated into improved design. Complete designs have now been prepared for a single-engined aeroplane, also a two-engined plane, having all-up weights of 5750 lb. and 10,000 lb. respectively. It is estimated that the times required for the production of the complete basic moulded panels from which these machines are assembled would be 82 hours and 135 hours respectively; it is stated that assembly of the finished panels is more rapid and less costly than construction by the present methods, since skilled and experienced labour is not required. The principal details of the proposed construction are shown diagrammatically in Fig. 5. The stiffening ribs, moulded integral with the wing or fuselage skin, are interesting features, also the bulb-ended form of the three wing spars and the siffeners on the spar webs. On the important aspect of joining, metal inserts for bolts or screws are stated to be unnecessary as the material itself holds a screw quite satisfactorily.

The progress of this development of the aircraft of moulded material will be followed with the greatest interest; it may prove to be the forerunner of a revolutionary step in aircraft design and in the use of a new material. That the skill and enterprise of the inventor and his associates will be rewarded with success is the hearty good wish of all.

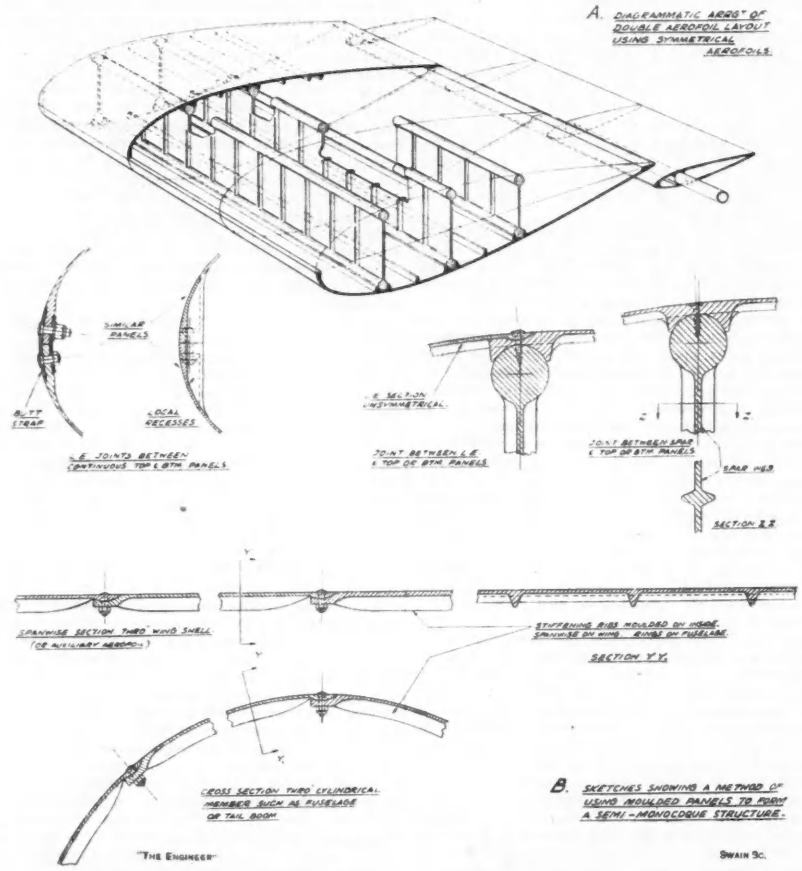

A. DIAGRAMMATIC ARRGT OF DOUBLE AEROFOIL LAYOUT USING SYMMETRICAL AEROFOILS.
SIMILAR PANELS
BUTT STRAP
LOCAL RECESSES
L.E. JOINTS BETWEEN CONTINUOUS TOP & BTM PANELS
T.E. SECTION UNSYMMETRICAL
JOINT BETWEEN L.E. & TOP OR BTM PANELS
JOINT BETWEEN SPAR & TOP OR BTM PANELS
SPAR WEB
SECTION Z.Z
SPANWISE SECTION THRO' WING SHELL (OR AUXILIARY AEROFOIL)
STIFFENING RIBS MOULDED ON INSIDE SPANWISE ON WING. RINGS ON FUSELAGE.
SECTION Y.Y.
CROSS SECTION THRO' CYLINDRICAL MEMBER SUCH AS FUSELAGE OR TAIL BOOM
B. SKETCHES SHOWING A METHOD OF USING MOULDED PANELS TO FORM A SEMI-MONOCOQUE STRUCTURE.
"THE ENGINEER"
SWAIN Sc.

FIG. 5—*Details of Proposed Aircraft of Moulded Plastic Construction.*

‡ "A New Wing." *The Aeroplane*, July 21st, 1937.

TRAMCARS FOR TORONTO, CANADA.

IN spite of a growing tendency elsewhere in the direction of substituting electric trolley cars for fixed railway cars in the city areas, the Toronto Transportation Commission has decided to expend 3,000,000 dollars on the purchase of 140 new street railway cars for use within the city areas. The new cars will be built by the Canadian Car and Foundry Company, and will make their first appearance on the streets some time in August. They will be modelled to the specifications of a research foundation formed some time back by the leading American street railways and manufacturers of street cars and equipment. Eight years ago the Presidents' Conference Committee undertook an investigation with the object of securing an approved design which would embody all that science could produce in safety, speed, comfort, and rider appeal. The final model is a streamlined vehicle which travels with speed, quietness, and smoothness, and is being known as the "P.C.C." car. During the past two years more than 800 cars of this new model have been produced and have been operating in several United States cities. The cars have rubber wheels and the car body and trucks and trolley pole base are "floating in rubber." The cars have rubber springs, rubber-filled wheels, and rubber-filled seats for riding comfort. The extensive use of welding, together with other factors, has made the new car 6000 lb. lighter than its predecessors. According to *Electrical News and Engineering*, Toronto, the strong, but lightweight, car is to be equipped with four Canadian Westinghouse 55 H.P., 300/600-volt motors, connected in series. Three braking systems combine to bring the car under control and to "cushion" the stops so that passengers are not thrown off balance. There are air brakes, electric motor brakes, and rail grip brakes that will hold in any weather. The car will keep pace with any traffic conditions it may meet in any city.

A New Tail End Booster.

THE advantages of boosters in rural and semi-rural areas for maintaining the voltage constant were fully described in the first of a series of articles appearing in our issue of November 24th, 1933. A new tail end booster of small dimensions and suitable for mounting on an ordinary network pole or in a manhole such as is used for the usual type of disconnecting box, has been introduced by the Hackbridge Electric Construction Company, Ltd., of Hersham, Walton-on-Thames, and is shown in the accompanying illustrations. It consists, as indicated in Fig. 1*a* and *b*, of a small transformer of which the primary winding may be either short circuited or connected across the line whilst the secondary is in series with the line. When the primary is short circuited the transformer does not give a boost, and the voltage drop resulting from the secondary reactance is very low. But when the primary is connected across the line a voltage is induced in the secondary, and according to the primary connections it bucks or boosts the line voltage. To limit the possible voltage rise during the instant of changing the primary

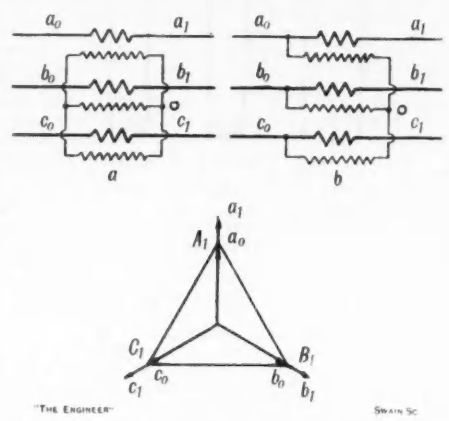


FIG. 1—ELECTRICAL DETAILS OF TAIL END BOOSTER

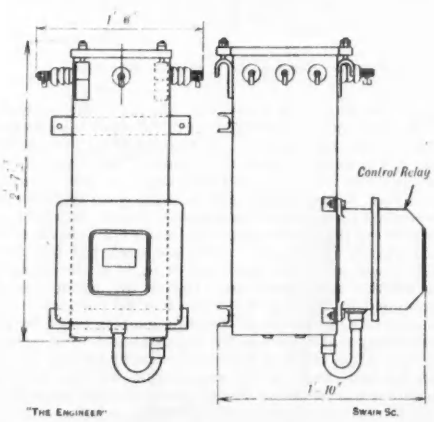


FIG. 2—BOOSTER FOR POLE MOUNTING

connections, the transformer is designed to have a magnetising current of approximately 30 to 40 per cent. of its full load current; but since it only comprises about 3 or 4 per cent. of the line current it does not affect the power factor of the line. Oscillograms are said to show that there is no appreciable over-voltage during the change over, and that the phase relationship remains unchanged, as shown by the vector diagram in Fig. 1.

In the case of the two-step booster, two auto-transformers are used mounted in one case (Figs. 2 and 3). The first of these transformers is connected as in Fig. 1*b* to give a definite boost whilst the primary of the second transformer may be short circuited—Fig. 1*a*—or connected across the line in either direction so as to give a buck or boost. If the boost be represented by x, then three conditions are available, *i.e.*, $x-x=0$ *i.e.* (no boost), $x+0=x$ (*i.e.*, half-boost), $x+x=2x$ (full-boost).

The control relay is a simple telephone relay of proved reliability, and special precautions have been taken to ensure that the booster will be cut in and out at exactly the same voltage value. A special circuit is employed to magnify the line voltage variations that are applied to the relay. Precautions are also taken to prevent the booster operating on transient voltage fluctuations, and a simple adjustment enables the user to alter the setting within fairly wide limits. When the load develops to an extent which makes the enlargement of the network capacity necessary, the booster can readily be removed and re-erected elsewhere. The unit illustrated in Figs. 2

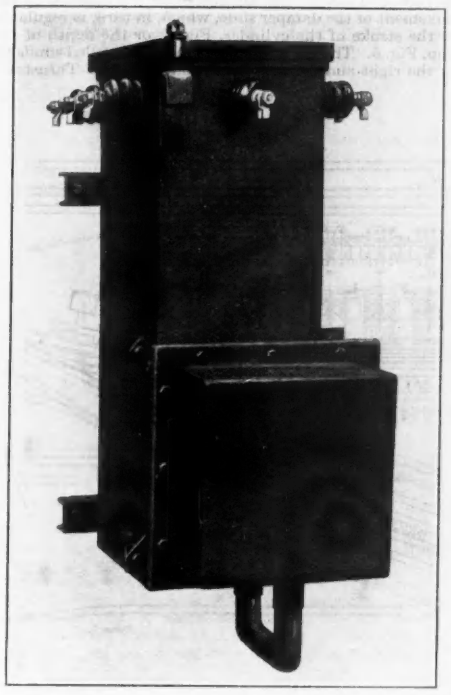


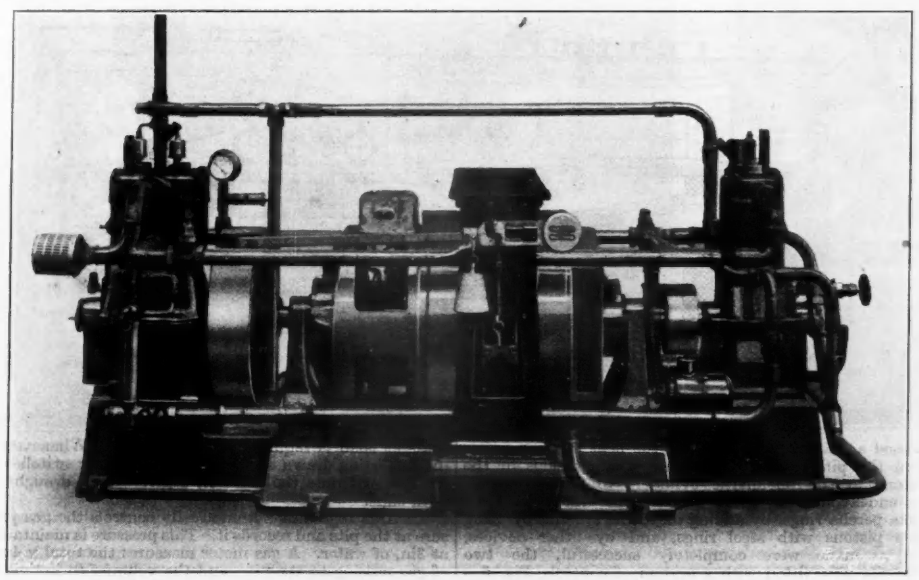
FIG. 3—COMPLETE TAIL END BOOSTER

and 3 is designed for pole mounting, and is housed in a fabricated sheet steel case with the relay unit in a separate compartment bolted to the front of the transformer unit; but if desired the transformer can be mounted at the top of the pole and the relay unit at a lower level to make it accessible from the ground. The booster may, as already explained, also be constructed for underground mounting.

Air Compressor Plant for Educational Purposes.

AN experimental air compressor plant under construction at the works of Broom and Wade, Ltd., High Wycombe, for use in Brighton Technical College, has a number of interesting features, which, it is claimed, render it particularly suitable for the equipment of engineering laboratories at technical schools, colleges, and universities. The accompanying illustration shows a plant of similar design which has been supplied to the Lester Institute, Shanghai, Coventry Technical College, and other educational institutions at home and abroad. The plant embodies two Broomwade single-stage water-cooled air compressors, similar to those described in the issue of THE ENGINEER for September 17th, 1937. The two compressors are coupled left and right-hand to a double-ended Mawdsley electro-dynamometer, suitable for working with a D.C. supply, and having an output of 10 B.H.P. over a speed range of 500–300 r.p.m. by shunt regulation. The left-hand compressor, which is solidly coupled to the dynamometer, is a two-cylinder machine with 4in. bore and 4in. stroke, having a displacement capacity of 28–16·8 cubic feet per minute at 500–300 r.p.m. The right-hand compressor is a single-cylinder model with 3in. bore and a piston stroke of 4in., having a displacement capacity of 8·2–4·9 cubic feet per minute, when running at 500–300 r.p.m. It is connected with the dynamometer by means of a "Standage" flexible coupling, which enables this compressor to be readily disconnected when not required. The compressors are mounted on a common iron bed-plate, and the equipment includes an intercooler and air receiver, not shown in the illustration.

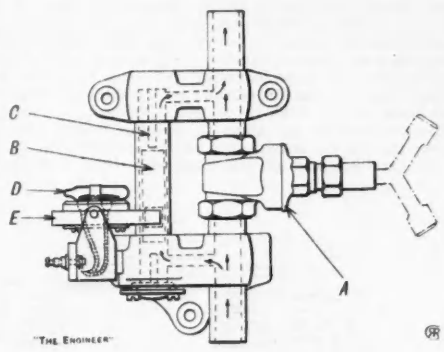
The plant is designed so that the compressors can be compounded, the right-hand machine serving as the high-pressure stage, suitable for pressures up to 200 lb. per square inch. Alternatively, the compressors can be run in parallel as a single-stage unit with or without after-cooling, and furthermore the larger compressor can be run alone with or without after-cooling. The water cooling arrangement enables the supply of water from each unit to be regulated, and the quantity of water from each unit of the total amount to be measured. Stop valves are provided on the water inlets of each machine, and by cross connections the water can be sent directly from one unit to the other. The compressed air is delivered into an air receiver, which is fitted with a variable setting relief valve. The plant is equipped with a permanent indicator gear to facilitate the taking of good indicator diagrams, whilst for the measurement of the air temperatures thermometer pockets are provided at the inlet, first-stage discharge, intercooler outlet, second stage discharge, and in the receiver. Thermometer pockets are also provided at the water inlets and outlets. The compressors are fitted with automatic unloading gear, and the equipment includes a British Compressed Air Society's standard ¾in. nozzle suitable for measuring air flows between 16 and 50 cubic feet of free air per minute, complete with U tube and nozzle pipe. The plant is, in fact, provided with all instruments required for technical college instructional duties.



EXPERIMENTAL AIR COMPRESSOR PLANT

Flow-Operated Cut-Out.

THE device illustrated below is likely to be of interest to all operating machines which would suffer damage were the flow of cooling or other liquid to cease or fall to too low a rate. It is made by Negretti and Zambra, of 38, Holborn-viaduct, London, and is intended to give

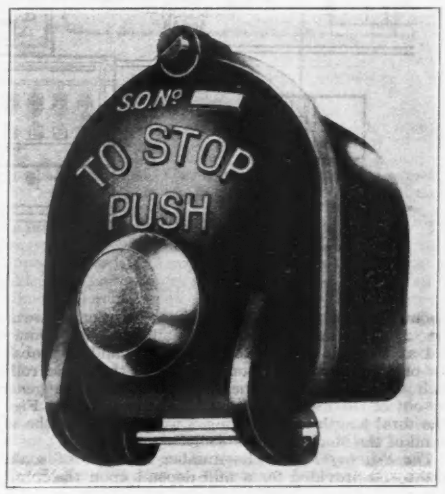


SAFETY CUT-OUT DEVICE

warning by electrical means of any such failure. An adjustable gate valve A with a detachable key is inserted in the pipe line and adjusted to restrict the flow and cause some of the liquid to rise through the by-pass pipe. In this by-pass there is a loose-fitting piston or plunger B, which is maintained in the upper position by the movement of the liquid. The gate valve is so adjusted that when the minimum safe flow of the liquid is passing the piston is just maintained in the raised position against the upper stop C. Should the flow fall below this safe level the piston drops. Its movement is transmitted magnetically to a pivoted magnet E, surrounding the tube, on which is mounted a mercury tube switch D. The tilting of the magnet causes an electric circuit either to be made or broken according to the type of circuit installed, and alarm bells, warning lights, automatic cut-out gear, or other devices are then operated. The piston of the device lifts when the head across the by-pass valve is about 8in. water gauge, and falls at about 6in. water gauge. The mercury tube has a carrying capacity of 2 amperes at 250 volts A.C. or D.C. The makers state that no damage can be caused even though the whole static pressure of the liquid system is applied to the inflow or outflow sides of the device. The only precaution necessary is that a suitable filter should be arranged on the inflow side to prevent the entry of dirt which might foul the piston.

A New Emergency Switch.

To meet the requirements of the new Factory Act, which comes into force on July 1st, calling for an efficient device for promptly cutting off the power in workrooms in the case of emergency, George Ellison, Ltd., of Perry Barr, Birmingham, has produced the switch shown in the accompanying illustration. A single blow on the large knob on the front of the switch interrupts the supply of power to a motor, and it is said that no matter how roughly the switch is used there is no fear of it suffering injury or of it failing to operate. The switch can be arranged



EMERGENCY SWITCH

to close a trip coil circuit of a circuit breaker or motor starter, or to operate the no-volt release coil. Any number of switches, rated at 5 amperes, 600 volts, can be provided in a circuit, and a switch can therefore be placed within easy reach of each machinist. In addition to the unit shown, four other types are made—a switch similar to that illustrated, but with a push-button protected against accidental operation by a shroud projecting above it; a switch enclosed by a glass panel which is broken by a hammer supplied with it; a lever-operated switch, and a flameproof switch for use in mines and similar situations.

HASTINGS MUNICIPAL AERODROME.—The Aerodrome Committee of the Hastings Town Council has recommended that no further work shall be undertaken in connection with the municipal aerodrome scheme, upon which £50,000 has already been spent. It has been found that runways of the length required by the Air Ministry cannot be provided.

ENGINEERS' PRECISION TOOLS.—The British Standards Institution has recently opened an extensive programme of standardisation relating to Engineers' Precision Tools in response to a request submitted by the Institution of Production Engineers. The Chairman of the Sub-Committee which will be responsible for the drafting of these British Standards is Mr. J. E. Baty. In accordance with the customary procedure of the Institution, the drafts of these Standards will be circulated for the general comment of interested organisations and firms, prior to their issue as British Standards. In view of the very wide applicability of these Standards throughout the engineering industry, an effort is being made to give these drafts the greatest possible publicity, in order that the views of purchasers may be available to the Sub-Committee. The first of the draft specifications, which is now ready for distribution, is for Surface Plates and Marking-off Tables—CE (ME) 7637—and draft specifications for Cast Iron and Steel Straightedges, for Dial Gauges, and for Vernier Callipers are well advanced, and will probably be issued for the general comment of industry before midsummer. Whilst it is probable that the bulk of those interested will be approached directly by the B.S.I., 28, Victoria-street, S.W.1, we may add that the Institution will be happy to send copies of the successive drafts to *bona fide* correspondents. Other subjects covered by the programme are: Block Gauges and Sine Bars; Plain Micrometer Gauges (Internal, External, and Depth); Dial Gauges; Engineers' Steel Scales, Steel Tapes, Contraction (Pattern-makers') Rules, Vernier Callipers (including Depth and Height Gauges), Gear Tooth Callipers; Feeler Gauges, Radius Gauges, Wire Gauges; Comparators, Sensitive Measuring Heads on Stands; Bevel Protractors; and Levels.

The Design and Operation of a Modern Blooming Mill.*

By W. F. CARTWRIGHT.†

THE 40in. blooming mill described in this paper feeds two mills, namely, a Morgan continuous billet and sheet bar mill, and a three-stand, three-high 21in. section mill. The blooms or slabs for the former go forward in a single length of 80ft., and the blooms for the latter in lengths from 8ft. to 16ft. The sizes fed to these two mills are various; there are blooms from 7in. by 7in. down to 5in. by 5in., and slabs from 12in. by 2in. up to 16in. by 4in., but by far the commonest size is 5in. by 5in.

In order to obtain the output required, the blooming mill was specified to roll 90 tons per hour of 5in. by 5in. blooms from a 3-ton ingot of the dimensions shown in Fig. 2. This mill rolls easily 5in. blooms for hours on end at the rate of 105 tons per hour, and is probably the only single-stand blooming mill in the world rolling such small blooms at such a high rate. The general lay-out of the mill and its auxiliaries is shown in Fig. 1. The total length from the ingot weighbridge to the first stand of the Morgan mill is 880ft.

The Soaking Pits.—The number and size of soaking pits to be provided for a mill depend upon the number and size of open-hearth furnaces or converters feeding them. For instance, in a mill fed by three 20-ton converters, hot steel arrives at regular short intervals, the heat consumed per ton of steel in the soaking pits is low, and the number of pits required is small. In fact, there are many works on the Continent where no gas whatever is used in the soaking pits, the internal heat of the ingot being sufficient to heat the exterior to rolling temperature. At Cardiff works there are three 230-ton tilting furnaces and two 80-ton fixed furnaces, and two further 250-ton tilting furnaces are now under construction. While the time for blowing a 20-ton converter will not vary more than a few minutes, the time from tap to tap for a 250-ton tilting furnace often varies by eight hours. This means that not infrequently at Cardiff there is a period of twelve hours without a furnace tapping, and then all five furnaces will be tapped within five hours. For an estimated weekly "make" of 7200 tons of ingots between 2 p.m. on Sunday and 1 p.m. on Saturday, a soaking pit capacity of 100 ingots in live pits and 140 ingots in dead pits was provided; the mill was specified to roll the ingots in twelve shifts from 10 p.m. Sunday to 1 p.m. Saturday.

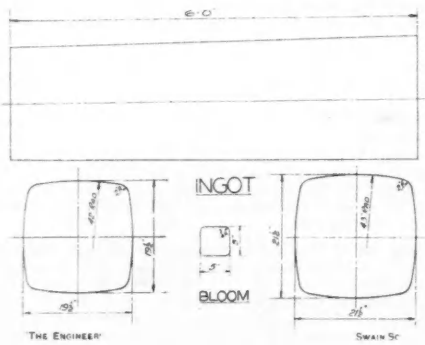


FIG. 2—*Ingot and Bloom.*

It almost immediately became apparent that the dead pits did not justify their own maintenance cost, which was considerable. The reason for their failure was the long and irregular intervals between taps. It frequently happened that the dead pits were filled with as many hot ingots as could be got into them, and the other ingots teemed at the same time had to stand in the open. When all the ingots had been transferred from the dead to the live pits, the ingots standing in the open were mainly "black hot," and for the next few hours there would be nothing to put in the dead pits, which therefore cooled off. When the next lot of hot steel arrived, the ingots charged into the dead pits would lose all their heat in raising the temperature of the pits again.

To avoid this irregularity, the tapping times of the tilting furnaces were separated by taking off one and two ladles instead of the normal three. This, however, reduced the make of the melting shop, and the stoppages for heat being still considerable, it was decided to increase the capacity of the live pits to 140 ingots by building two more. At the same time, the dead pits were demolished. Where the practice is to empty the furnace at every tap, the use of tilting furnaces entails a large soaking pit capacity. The supply of steel to the mill is so irregular that, in effect, it can be said that the pits are charged with 50 per cent. hot and 50 per cent. cold steel.

There are now seven double pits at Cardiff works, each double pit holding twenty ingots. They are of the Isley control type and were originally designed for firing with cold gas of 120 B.Th.U. per cubic foot calorific value, maintained by mixing coke-oven gas with blast-furnace gas, using an Askania regulator. This, however, proved unnecessary, as a temperature sufficient to make an ingot "squat" can be reached with cold blast-furnace gas alone, of 102 B.Th.U. per cubic foot calorific value, and blast-furnace gas alone is therefore used. Fig. 3 shows the general arrangement of one of these pits.

The first five soaking pits built were fitted with compressed air control—Fig. 4—but the heat blowing across from the pits caused the leather packing rings of the pistons in the pneumatic cylinders to leak seriously. An endeavour was made to overcome this by fitting gutta-percha rings, by adding oil to the system, by using deep pistons with steel rings, and by other devices, but as none were completely successful, the two new pits were fitted with a system of control—Fig. 5—consisting of a small electric motor on each plunger driving a small centrifugal pump; when the motor is switched on, it pumps the plunger up. The control links were modified slightly for this system. They have proved a complete success and require no maintenance other than oiling. The first cost of this system is, however, much higher than that of the pneumatic system unless the cost of the compressor is included, in which case it is approximately the same.

The reversing system on all pits is the same. With air and gas on at the left end, the gas valves at that end are open, and the right end gas valves shut. The butterfly valve in the left end chimney is shut, and in the right end chimney open. The "Thrustor" or pneumatic cylinder on the left end air and draught control is up, and that at the right end down. The amount of air is controlled by the movement of the damper slide, which, in turn, is regulated by the stroke of the cylinder, Fig. 4, or the depth of the stop, Fig. 5. The amount of draught is controlled similarly by the right end cylinder and the right end "Thrustor."

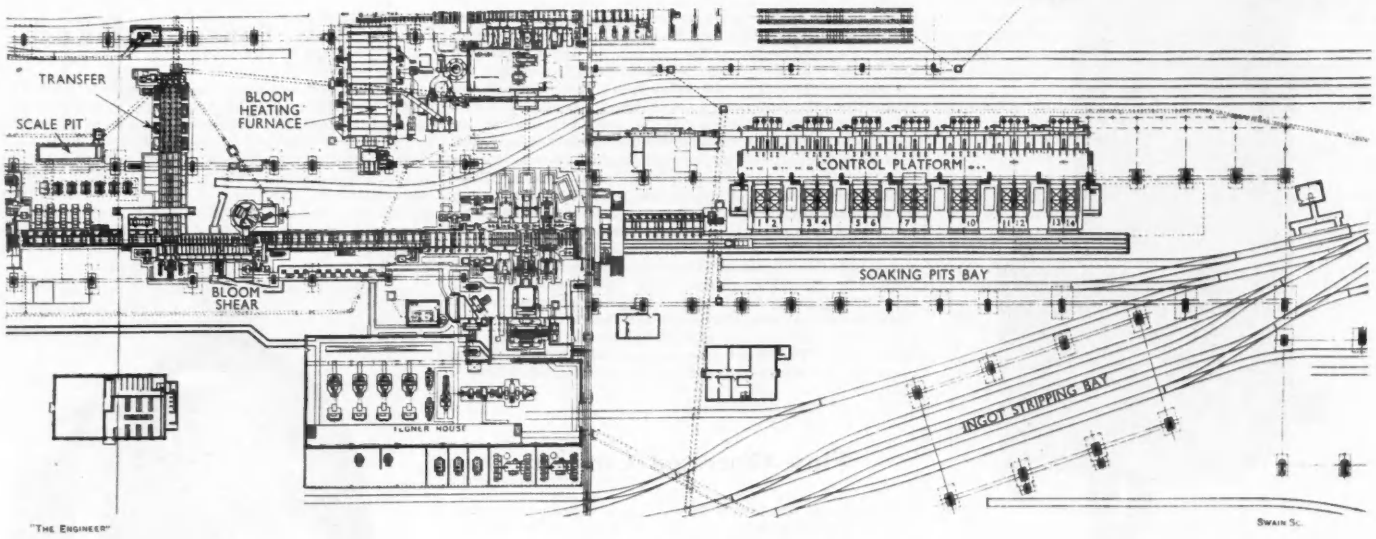


FIG. 1—*General Arrangement of Mill.*

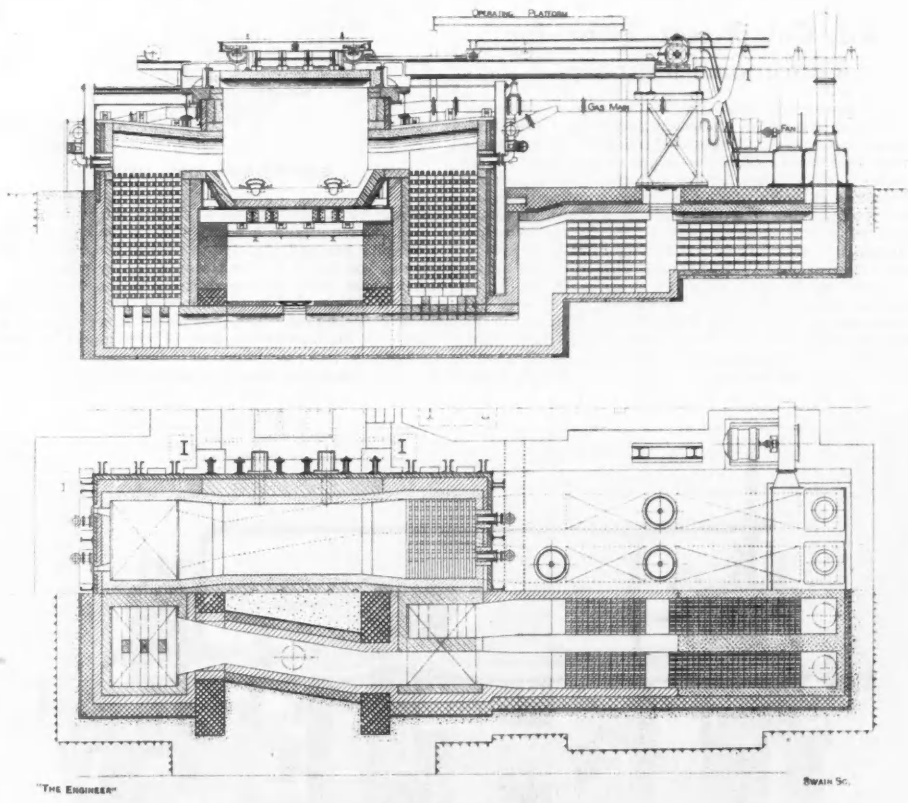


FIG. 3—*General Arrangement of Soaking Pit.*

To reverse, the left end gas valves are closed, the butterfly valve in the left end chimney is opened, inducing draught by the ejector effect of air blowing up the chimney, and the butterfly valve in the right end chimney is closed, causing combustion air to be blown through the chequers to the right port end. Simultaneously, as the controls are interlocked, air is admitted or current switched on to the pneumatic air and draught cylinder for the left end, and turned off at the right end. In the case of the left end the slide rises slightly, in the case of the right end it falls slightly, as more air is required to induce the necessary draught than is required for combustion. Whenever an ingot is being drawn or charged, the operator switches off the gas and puts the pit "on centre," with draught on both ends.

An Arca regulator automatically controls the gas pressure at the pits and records it. This pressure is maintained at 3in. of water. A gas meter measures the total volume of gas passing to the pits, and the volumes to individual pits may be separately measured if desired for the purpose of combustion tests. By making the branch gas pipes,

* Institution of Mechanical Engineers—Cardiff Summer Meeting, May 31st.

† Technical assistant to the managing director, Guest, Keen, Baldwins Iron and Steel Company, Ltd.

valves, and burners on all pits uniform, it has been found possible to control the conditions in the pits by combinations of gas, air, and draught valve settings for various volumes of gas consumed. With the gas full on, it is found desirable to maintain a slight excess of air in the waste gases, in order to obtain sharper combustion. When a pit is being held, the lower settings come into effect when a slight excess of unburnt fuel gas is allowed in the waste gases.

The results obtained with this method of combustion control are so satisfactory that it appears doubtful whether the cost of automatic control can be justified. It is, however, possible that it would be an advantage to have the gas and air volumes recorded on each half-pit.

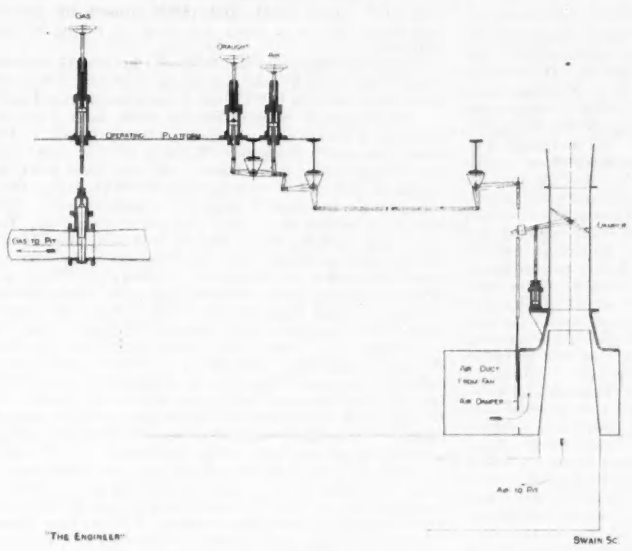


FIG. 4—*Diagram of Isley Control (Compressed Air Method).*

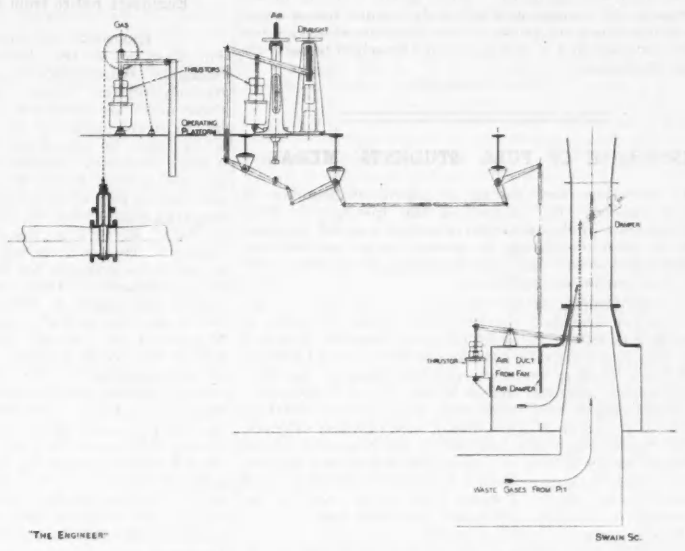


FIG. 5—*Diagram of Isley Control ("Thrustor" Method).*

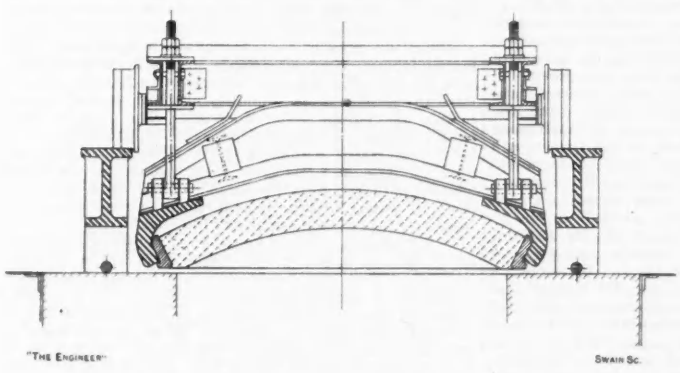


FIG. 6—*Soaking Pit Cover.*

It was with this in view that the last two pits were provided with a separate fan for each half-pit, instead of one for the whole pit. In order to record the volume of air, a suction tube has to be mounted on the fan intake and a diaphragm inserted to measure differential pressures, as there is no other straight length of tube in the system.

The pits were designed to enable the slag to be tapped out at the side. A certain amount is, in fact, tapped out, but owing to the amount of cold steel charged and the two-shift working in the mill, it has been found impossible to prevent the bottoms growing. Therefore, after about eight weeks' work, when the slag has grown to within 4in. of the bridge, the slag is cut out at the week-end. It is the practice to "sound" the depth of the bottom of each pit each week. After cutting down, the bottom is made up with basic slag and scale. Unfortunately, this method of working renders the slag of little value owing to intermingled bricks.

An additional reason for the failure to tap off slag regularly is the use of one-piece doors. The type in use, Fig. 6, is very satisfactory in every other respect, as it is extremely tight, and low in maintenance cost. It consists of a mild steel chassis with four wheels running on water-cooled cast steel girders. From the chassis is suspended a firebrick arch held in a cast steel frame. The sealing of the door is effected by the four wheels running into slots in the rails, thus lowering the door into the fully closed position. Owing to the flexible suspension of the doors from the chassis, there is very little drag when the wheels move out of the slots; the chassis moves some way before the door moves, and the door then comes away with a slight jerk.

The covers travel to and fro from the control platform, and it had been the intention originally to draw and charge half the ingots in each pit with the cover driven towards the platform, and half with the cover driven away from the platform. The ingots would then be drawn out through the Y-piece connecting the driving arm with the chassis. In that way the pit should never be more than half uncovered. But in practice it was decided that the risk of dropping an ingot on the expensive door was too great, and all ingots are therefore drawn and charged with the cover driven towards the control platform. Hence for the last two ingots the whole pit is uncovered, chilling the bottom considerably and completely preventing slag tapping. These difficulties have been surmounted in the latest American pits by causing the covers to travel from side to side with the driving motor on the cover, instead of using a rack and pinion drive. In this type the covers are raised electrically before travelling, enabling a very tight fit to be obtained.

The Ingot Chariot.—The ingot chariot at Cardiff works is of particular importance because the heavy live-roller track is too short to permit the soaking pit cranes to deposit an ingot on it. Such a short roller track effected a very considerable saving in capital cost, but meant that the whole mill depended on the chariot. It was therefore made of exceedingly heavy construction; in working order it weighs 30 tons. An ingot can be dropped on it from a height of several feet without causing any damage whatever. Figs. 7 and 8 illustrate the ingot chariot.

The control is from a cabin mounted high up on the crane columns near the mill. The power is picked up in a trench between the rails, where there are six collector wires. This part is the only one which has given any appreciable trouble. Owing to the depth of the trench it is not really possible to tie the rails accurately to gauge. A slight movement, due to expansion of the soaking pit foundation, disturbed the concrete and the gauge. The rails were not continuously supported and an ingot dropped between two supports always caused the rail to buckle, this being aggravated by the fact that a rail of shallow section had been chosen. The conductor wires are not readily accessible as the cover plates have to be removed. These cover plates also get broken by falling ingots.

A more satisfactory arrangement would have been to tie the rails by sleepers, supporting them throughout their length on joists, and to bed the whole in concrete, replacing the conductor wires by copper-headed rails under the shelter of the pit guards. It was found impossible to control the tipping operation by a limit switch, and the control is now wholly in the hands of the operator.

The Main Mill Motor.—The main mill motor is of the single-armature reversing type, and has a peak capacity of 18,800 H.P. Its full output speed is 62 r.p.m., and maximum speed 150 r.p.m. The motor operates from 0–1470 volts and has a nominal continuous rating of 6650 H.P. The time of reversal from 62 r.p.m. in one direction to 62 r.p.m. in the opposite direction is under two seconds. Up to the speed of 62 r.p.m. in each direction the motor will give a torque of 230 metre-tons or 169,000 lb.-ft., and at higher speeds the torque falls as the speed rises, the horse-power then being approximately constant.

The armature has a total weight of 58 tons. It is supported in two pressure-lubricated bearings, 25in. in diameter at the driving end and 23in. at the commutator end. The weight of the complete machine is 143 tons. The cooling air is cleaned and then passed through the machine at the rate of 38,000 cubic feet per minute.

Direct current is supplied to the mill motor by an Ilgner set, the three generators of which are connected in series with the mill motor armature, no switchgear being interposed. Each generator is rated at 1740 kW, 490 volts,

FIG. 7—*Ingot Chariot at Rest.*

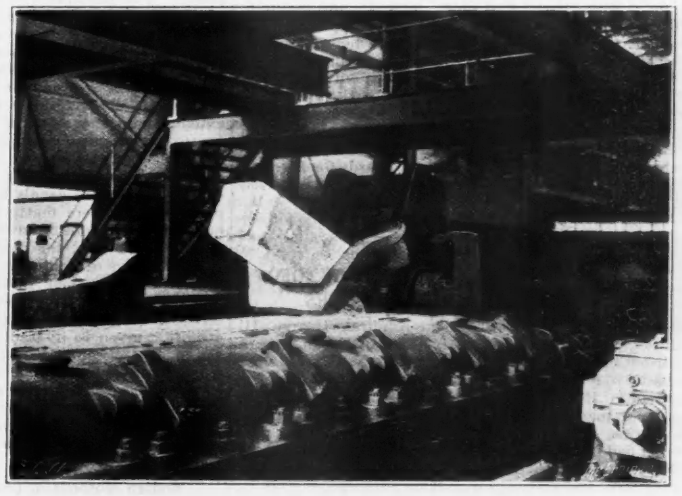


FIG. 8—*Ingot Chariot Tipping.*

and the set is driven by a 5000 H.P., 3300-volt slip-ring motor with a synchronous speed of 600 r.p.m. A fly-wheel of 41½ tons weight and 11ft. 6in. diameter brings the total rotating weight of the set to 70 tons, and the inherent inertia is therefore 208,000 H.P.-seconds. The peripheral speed of the fly-wheel is 250 m.p.h.

The object of fitting a fly-wheel on the generator set is to avoid excessive peaks in the load taken from the electrical

supply. To utilise the energy conserved in the fly-wheel the speed of the set is allowed to fall by inserting resistance in the rotor circuit of the 5000 H.P. driving motor. This operation is entirely automatic. The stator current is passed through a series transformer, the secondary winding of which is applied to the stator of a slip-ring torque motor operating a variable liquid resistance in the rotor circuit of the main driving motor. Thus, as the load on the set increases, the voltage applied to the torque motor rises, the motor raises the plates of the liquid resistance, slows down the main motor, and allows the fly-wheel to carry its share of the load.

(To be continued.)

INSTITUTE OF FUEL—STUDENTS' MEDAL.

To encourage the reading of papers by students of fuel technology, the Council of the Institute of Fuel has decided to make an annual reward of a medal, together with a prize consisting of books and/or instruments to the value of £5. The rules governing the award of this prize and medal are as follows:—

(1) The Council of the Institute of Fuel invite competition for a medal, together with a prize of books or instruments to the value of £5 to be awarded annually for a paper submitted by a student member of the Institute of by any student under twenty-five years of age of a university or technical college in the United Kingdom.

(2) The paper shall deal with some subject relating to the preparation or utilisation of fuel, or allied subjects.

(3) Papers must be submitted to the Secretary of the Institute under a *nom de plume*, the name and address of the author being enclosed in a sealed envelope and sent with the paper. Papers must be received by the Secretary on or before September 1st in any year.

(4) The name of the successful competitor in each year will be announced at the October meeting of the Institute, and the award presented at the annual dinner, at which the prize winner will be the guest of the Institute.

(5) Papers must be limited to a maximum content of 6000 words, and may be illustrated by line drawings or photographs.

(6) One medal and prize will be available for award each year.

(7) The Institute reserves the right to withhold granting a medal in any year if, in the opinion of the Papers Committee, no applicant deserves the award.

(8) The paper earning the award may be published in the *Journal*.

(9) A list of medal holders to be included in the published List of Members of the Institute.

(10) In judging the papers submitted, consideration will be given to :

(*a*) Subject matter.

(*b*) Evidence of analytical power and logic.

(*c*) Construction of paper in so far as it gives evidence of an orderly mind and shows continuity of argument with an orderly development of the theme.

(*d*) English.

All papers submitted for this competition must be addressed to the Secretary, the Institute of Fuel, 53, Victoria-street, London, S.W.1.

HANDBOOK OF RAILWAY STATIONS.

A REVISED edition of the official "Handbook of Railway Stations" has been prepared and is now ready for issue by the Railway Clearing House. The book consists of 654 pages, contains upwards of 50,000 entries, and gives an alphabetical list of stations, sidings, collieries, junctions, works, &c., on the railways of Great Britain and Ireland, together with the county in which each is situated and the exact geographical position.

The accommodation at each station is indicated, showing the tonnage of fixed crane power available (in addition to which most of the railway companies have travelling cranes with a lifting power of 5 tons and upwards which can be moved from one station to another as circumstances require), whether goods stations, passenger and parcels stations, places where coal class, mineral, and S. to S. traffic in truckloads is dealt with, where parcels and miscellaneous traffic only is handled, where furniture vans, carriages, motor cars, portable engines, and machines on wheels can be dealt with, livestock entrained and detrained, and horse-boxes and prize cattle vans, and carriages and motor cars by passenger train accommodated.

Copies of the "Handbook of Railway Stations" can be obtained from the Railway Clearing House, Seymour-street, Euston-square, N.W.1, in cloth boards for 10s. 6d., including carriage, and in half leather and interleaved with ruled paper at 45s., including carriage.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

ON Tuesday June 28th, Rear-Admiral George H. Rock (CC), U.S.N. (ret.), the late Chief of the Bureau of Construction and Repair, United States Navy, will visit Newcastle to receive the Institution's Diploma of Honorary Fellowship. He will be accompanied by a representative number of members of the Society of Naval Architects and Marine Engineers, U.S.A., and the following programme has been drawn up for their entertainment :—

10.30 a.m.: Presentation of Diploma of Honorary Fellowship of the Institution at King's College.

12.45 p.m.: Civic luncheon to Institution's guests.

2.15 p.m.: (*a*) Trip on the Tyne. The Tyne Improvement Commissioners are kindly granting the use of their launch "Sir William Stephenson" for the purpose ; (*b*) Visit to the Roman Wall or other places of interest.

7.30 for 8 p.m.: Dinner by Institution, followed by dance.

The party from the United States will include a number of distinguished American shipbuilders and engineers, headed by the President of the Society of Naval Architects and Marine Engineers, Mr. Joseph W. Powell. A list of the names of the visitors will be available later.

Engineering Notes from China.

(By our own Correspondent.)

HONG KONG, April 7th, 1938.

Engineers Retire from China.

RESIDENT for more than thirty years in the Far East, all of the time spent in the service of the Shanghai Waterworks Company, Mr. C. D. Pearson recently left for "home" and will be in England when these notes are published. He has taken a major part in the development of the water supply for Shanghai, which, since he joined the company, has increased from a daily output of 7,000,000 to 60,000,000 gallons. After graduation from Bristol University, Mr. Pearson joined a well-known firm of consulting engineers and then became assistant engineer for the Shanghai Waterworks Company in 1904. In 1925 he was appointed chief engineer and manager. He has, in the last five years, had great anxieties in maintaining supply for Shanghai during two invasions by the Japanese ; there can be no doubt of the great respect and gratitude which he has earned in Shanghai for his devotion to duty, especially during recent months. In spite of the constant criticism of the clever-ignorant writers who know nothing of science, and who complain of the monotony of life, which they say is caused by mass production and mechanism, Mr. Pearson and other engineers in China have had plenty of excitement and have had demands upon their courage and resourcefulness during their careers in the Far East. They have, indeed, needed other outstanding qualifications besides a knowledge of technology. It must have required great courage to continue the public utility services in Shanghai in those months of constant bombardment, when precautions against shells and bombs from the air had to be taken. Technical descriptions of the waterworks of Hong Kong, Shanghai, and Yokohama, were presented in papers included in the "Proceedings" of the Institution of Civil Engineers for 1890, and there was an animated discussion. Those engineers who took part in it advocated an extension of modern water supply systems in the Far East on humanitarian grounds. General Scott said that, to his mind, it was the engineer who stood the best chance of breaking through the crust of prejudice, distrust, and dislike which still formed a barrier to intercourse with Europeans, and to the material progress of those countries. Since those words were spoken water supply in the Far East has been greatly extended. There are now several towns and cities in China with modern systems. The figures quoted above concerning the increase in demand for water in Shanghai, during the period of Mr. Pearson's work there, reveal, also, the growth in population of Shanghai ; but other urban centres have also expanded. Shanghai obtains its water from the Whangpoo River. An enormous quantity of unpleasant and undrinkable water is taken out of the stream and purified. It has been said that anyone who is unfortunate enough to be submerged in the Whangpoo River runs a great risk of cholera, and although the disease is a peril in Shanghai, it is certain that it has never been due to the water supply. It is worthy of note that Mr. Pearson and Dr. Herbert Chatley—who recently retired from Shanghai as Chief Engineer of the Whangpoo Conservancy Board—were two British engineers who did a great deal of work in connection with the Engineering Society of China. Both were interested in technical education and were successful in providing Chinese engineering graduates with opportunities to obtain useful practical experience, with careful supervision under men who had high ideals concerning their profession.

A Man's Work in China.

One of the most prominent engineers in the Far East, an American graduate who found his life work in China, is also retiring from the country, where he has left evidence of a lasting nature of his work on behalf of the Chinese nation. Major Todd probably knows more about the economic conditions of the Chinese people and civil engineering works in that country than any other person. Famous throughout the world for their ancient civilisation, which produced a remarkable literature and a unique social system, at a period when the inhabitants of Britain were burning human captives in wicker cages and painting their bodies with woad, it is well to emphasise that, from the dawn of their history, the civilisation of the Chinese people depended, to no small extent, upon the work of those concerned with water control. Agriculture was, and is to-day, the basis of the prosperity of the nation, and agriculture was, and is, dependent in China upon hydraulic schemes. Flood control, irrigation, canals for the transport of grain and people—those were matters of vital importance for the hundreds of millions of farmers, peasants, officials, traders, and scholars who, for more than twenty-five centuries since the days of Confucius, depended upon the products of the land for their sustenance. Ingenuity, industry, and perseverance have always been outstanding characteristics of the Chinese people. Yet great as was the attention given to hydraulic problems, their schemes for water control and irrigation until this century were, when compared with modern methods, disconnected and even haphazard. There was no reliable data concerning rainfall, velocities of rivers, silt, and other factors vital for the solution of the difficult problems which face the hydraulic engineer in China.

Modern Methods in China.

During the last twenty years there has taken place a revolution in the methods of dealing with these details of water control in a land of 450 million inhabitants. Areas frequently afflicted with floods and famines were carefully surveyed. Important details connected with the topography of the country were collected. Plans for comprehensive schemes were made and works were designed and carried out so that anything done in one district would not do harm elsewhere. In a word, the experienced and scientifically trained engineer had come to China and realised that the vast area provided for him in that country, for his work on behalf of suffering humanity, gave him an opportunity to demonstrate that his professional training could be used for the highest purposes known to mankind. Whatever may be the future of China, Major Todd will long be remembered in that country as an engineer of ability inspired by the highest ideals. The romance of his career of eighteen years on civil engineering works and surveys, when he frequently faced death and perils caused by bandits, epidemics, &c., is a story too long to relate in these columns.

About five years ago the Dean of Canterbury travelled across China with this American engineer, whom the Dean described in a B.B.C. broadcast address from London as "the engineer responsible for more large-scale construction works in China than any other engineer." They went through Mongolia, Western China, and Tibet in a Dodge lorry over deserts, ravines, river beds, and gradients of 1 in 3, over mountains 10,000ft. high. Petrol consumption averaged 5 miles to the gallon ; men, mules, and oxen helped them over the worst obstacles. They were back into the China Marco Polo saw, the China of pigtails and of bound feet, the districts where Western ideas had failed to permeate. Midway to Tibet, they saw the Luipan Pass, 10,000ft. high, the worst obstacle between Central Asia and the coast. Since the days of Marco Polo travellers had dreaded the pass ; but they now dread it no longer, for Todd has built a new road, 10 miles long, that provides a gradient that nowhere exceeds 7 per cent. Man-drawn rickshaws have traversed the new road and cars have ascended it on top gear. The 10-mile road cost £6000, of which sum America supplied £3000. "It is hard," said the Dean, "to imagine a more splendid work than this of the engineers. . . . It teaches the Chinese to develop their own resources and preserves their self-respect. It saves a helpless people from a terrible death." For Todd and his engineering associates have saved many thousands of lives in China from famine and flood by their works of road building and hydraulic engineering schemes.

Leadership Essential in China.

Major Todd spent the first nine years of his career as an engineer in California, and then took an active part in major construction projects as a Captain of Engineers with the American Expeditionary Forces in France. Immediately after his return from war service he went to China to assist John R. Freeman in his investigation concerning improvements for the Grand Canal in Shantung. In 1921 he took charge of the American Red Cross work in Shantung, where he carried out the work of building 500 miles of earth motor roads in 90 days with famine labour. Soon afterwards, in China's most inaccessible province, Kweichow, he was directing 200,000 peasant farmers employed in building modern motor roads, mainly for famine relief purposes. The country was bandit-ridden ; he travelled for weeks on foot and horseback over rough mountain trails. This great work of road building in a province that was entirely without wheeled vehicles up to the summer of 1927 is the greatest piece of public utility construction in China since the building of the Grand Canal and the Great Wall.

It will always be in connection with flood prevention and irrigation, however, that Major Todd will be remembered in China. For eighteen years he has constantly studied these hydraulic problems in nearly every province. Possibly his most notable feat was in connection with the lower Yellow River in 1922–23, when he successfully carried out a daring plan for turning the entire flow of that river back into its former bed, after it had followed a new course for some months.

As Chief Engineer of the China International Famine Relief Commission, Major Todd travelled 80,000 miles in China, a great deal of it on foot, during his last four years in the country. He planned a big programme to put an end to famine in China by increasing transport facilities for grain and other food from prosperous districts to those where there were crop failures. Further, he increased China's food supply by river control and irrigation improvements. It may be possible to describe in detail some of this remarkable work at a future date, but it is of interest to relate that in the district where there has recently been heavy fighting in North China he carried out remarkable irrigation projects which water 100,000 acres of land. He rebuilt 480 miles of main road from Sian to Lanchow (near where there has recently been active warfare), making many land changes and reducing all gradients to a maximum of 7 per cent. He made extensive calculations for developing 50,000 H.P. of hydraulic electric energy from the Yellow River, at an estimated cost of about £600,000. This present conflict in China has delayed progress, and has possibly destroyed some of the works carried out by Todd and his associates. But much of it will outlive the actions and reactions of politicians, will survive the bickerings and quarrels of nations, remain intact while those who to-day are scrambling in the hurly-burly of fluctuating currencies and mercurial markets will be ashes or skeletons buried in the earth.

In this century we have witnessed astounding political upheavals, amazing reshapings of the map of Europe, incredible changes in outlook on life of many of the people in Asia. While all these things were passing across the flickering screen of time, many of these events startling enough to shake our faith in the future, in all parts of the world men have been building works that shall outlive them, and that will benefit their own and future generations.

The China of to-day is not the China of Marco Polo ; it is a land that, in spite of the ruthless destruction of many buildings and other works of the engineer during recent months, has been affected by technology in other and better ways. For the work already accomplished by such men as Todd, Eliassen, Stroebe, and others in connection with water control in China, will remain to benefit the nation when the forces of destruction due to invasion have been exhausted. Meantime, wherever it is possible to work, efforts are being made to adopt modern methods of construction. There are now many Chinese engineers with high scientific qualifications and considerable practical experience, who are actively engaged on constructional and other works in their own country.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Continental Steel Cartel.

Important meetings of the Continental Steel Cartel were held in Rome last week, but eventually it was decided to adjourn until June 16th, as the Belgian steel makers had not been able to obtain unanimity with regard to their quota arrangements. It is understood that the firm of Gustave Boel, of La Louviere, has stood out for an increase in its export quota or a substantial indemnity to which the other Belgian firms have refused to agree. Apparently, as a result of the discussions in Rome, the recalcitrant firm has now consented to abide by the arbitration of the Belgian Government. It is generally believed that the difficulties will be overcome and that the Cartel agreements which are due to expire at the end of June will be renewed at the meeting on June 16th. It was anticipated that the question of export prices would be discussed and in some quarters it was thought that quotations might be reduced. According to report, however, the British steel makers are averse at this juncture to a revision in this direction, and have opposed any negotiation on the subject until the Cartel agreements have been renewed for a further period. American representatives, as well as British, were present at these meetings, but consideration of the international agreement to which they are a party was postponed. It is understood that a meeting is to be held in London shortly at which problems regarding the position of the Americans will be considered. A meeting of the Continental and British tin-plate makers resulted in the Americans being conceded a larger quota. For some time past, and with the consent of the other parties to the international tin-plate agreement, the American makers have exceeded their quota, and apparently the increased tonnage now allotted them will adjust the position. In the meantime, the general situation on the export markets is far from favourable. Business from practically all overseas countries has seriously declined in Continental as well as in British steel, and there is a general tendency on the part of buyers to wait until the Cartel has been renewed and a decision reached upon price policy. In spite of threats which were made at the Cartel meeting held a few weeks ago as to the consequences of breaches of the price agreements, reports are continually being received by London merchants of concessions being made upon the official rates in order to secure orders for even small parcels of steel.

The Pig Iron Market.

Business in all descriptions of pig iron continues to be transacted upon hand-to-mouth lines. Consumers are content to work upon their stocks, and as a consequence there is very little new business passing. The demand for foundry iron has shrunk to small proportions, and in a number of cases consumers have suspended deliveries against existing contracts. Some of the uncertainty regarding prices has been removed by the announcement by the Pig Iron Producers' Association that current quotations will be stabilised until the end of the year. The previous statement was merely to the effect that there would be no change in the prices of foundry pig iron after June 30th, when the present period of stabilisation was due to expire. This decision will cause disappointment to users who had been expecting a reduction at the end of July, and presumably will now have to wait for a further six months. It is practically impossible to say what stocks of foundry iron exist in the country, but it is known that there are heavy accumulations at the producing and consuming works. Nevertheless, the fact that the demand remains so poor is an indication that the stocks are being steadily absorbed, and since no further importations of foundry are likely owing to the operation of the rebate scheme and the tariff, the period must be approaching when the accumulations will be reduced to a normal level. In the meantime, the producers are restricting production. On the North-East Coast one furnace is producing foundry, and this output is more than sufficient for the requirements of the market. There has been practically no forward business transacted of late, and now that prices have been stabilised for a further period, it is unlikely that buying of this description will develop for some time. In the Midlands the quietness ruling at the light castings foundries is reacting upon the demand for pig iron, which at the moment is not sufficient to absorb the whole of the make. In Scotland, also, a certain amount of the production is being put into stock, and there is talk of furnaces shutting down. The demand for basic and hematite iron has slackened during the past few weeks, and most of the steel-producing plants have larger supplies on hand than they require. A further restriction of output is expected, and it is anticipated that Dorman, Long and Co., Ltd., will shortly blow out four blast-furnaces at their Cleveland works. These, however, are old furnaces, and their productive capacity is not large. Export trade in any description of pig iron is difficult to arrange owing to the competition of foreign makers. Reports of very cheap prices at which Continental foundry iron is being offered continue to circulate, and £3 to £3 5s. f.o.b. has been mentioned.

The North-East Coast and Yorkshire.

There is little expectation that conditions in the iron and steel trade on the North-East Coast will improve until the opening of the third quarter. Expectations are rife that at the end of May an improvement would take place in the volume of business, but these have not yet been realised and the tonnage of new orders reaching the works, if anything, seems to be dwindling. The market is still congested by heavy stocks of iron and steel, and until these are reduced to more normal proportions it is difficult to estimate the true situation. There is still a large tonnage of steel passing into consumption, but whilst prices are stabilised for long periods in advance and consumers can obtain their requirements practically at once, there is no inducement to book forward. There have been repeated statements that the demand is seriously falling, and no doubt there is some truth in this, although how much of the decline on new business is due to consumers working on stocks and old contracts it is difficult to say. Still it is a fact that the reserve of contracts in the hands of the works which remains to be dealt with has been very much depleted. The heavy steel works on this coast continue to produce at a high rate, although the makers are now anxiously seeking new business. Deliveries also have been reduced to two or three weeks. Recently one or two good contracts have been placed for structural steel and this has raised hopes that an improvement is at hand in this department. The production of billets has been considerably reduced to bring it into line with the demand. This section of the industry is severely affected by the heavy stocks of Continental steel which were imported in the early part of this year. Fresh arrivals from the Continent are expected shortly under the terms of the Cartel agreement, and it is feared that these will add to the congested state of the market. The re-rollers are feeling the effects of the shrinkage in demand plus the large stocks to a greater extent than the heavy steel makers. In the Sheffield district, also, the decline in new business is causing some concern. The departments producing special steel, however, appear to be fairly well off for business, and are anticipating a revival in the demand for their products when the rearmament programme is accelerated. The expansion in aeroplane construction has resulted in the maintenance of the demand for steels used in this work. A decline is noticeable in business in stainless steel.

Current Business.

It is announced that the Lowmoor Iron Company (Successors), Ltd., has been formed to deal with cold-blast pig iron manufactured under the "Lowmoor" brand, and is in no way connected with Lowmoor Best Yorkshire Iron, Ltd., manufacturers of wrought iron, whose rolling mills are at Low Moor. The old blast-furnaces at Low Moor are being dismantled by Thos. W. Ward, Ltd. Robert Sorby and Sons, Ltd., edge tool makers, of Kangaroo Works, Woodseats, Sheffield, are to erect a hardening shop in Chesterfield-road. Henry Robb, Ltd., Leith, have received an order for a motorship of 3050 tons for the Union Steamship Company of New Zealand, Ltd. Harland and Wolff, Ltd., have secured a contract for the steelwork for an aircraft factory to be erected by Short Brothers, Ltd., at Rochester, Kent. John Lysaght, Ltd., have arranged for weekly calls at their Newport River wharf for vessels bringing tin-plate bars from Scunthorpe, Lincs. Hitherto these bars have been transported by rail. The Admiralty has placed an order for a tug and salvage vessel of 840 tons with Fleming and Ferguson, Ltd., Paisley. Greenock Dockyard Company, Ltd., has obtained an order for a twin-screw cargo steamer of 10,000 tons deadweight for Clan Line Steamers, Ltd. The propelling machinery will be supplied by John G. Kincaid, Ltd., Greenock. The Association of British Chambers of Commerce has been asked to make representations to the Board of Trade on suggestions submitted by the Glasgow Chamber of Commerce that if it was decided to buy aeroplanes from the United States, it should be a condition of the contract that orders for ships to the equal value of the aircraft should be placed in Great Britain. A scheme for highway development in the City of Lincoln, which will cost over £200,000, has been approved in principle by the Minister of Transport. It will involve the construction of a concrete viaduct over the railway, the widening of a bridge and certain streets, and the replacement of a privately owned swing bridge by a fixed structure. The Department of Overseas Trade announces that the following contracts are open for tender :—New Zealand Posts and Telegraphs Department : 2½ tons of soft solder for general electrical purposes, in sticks having a nominal length of 16in. and a nominal weight of 8 oz.; 2 tons soft solder for lead cable wiped joints, in sticks of a nominal length of 16in. and a nominal weight of 16 oz. (Wellington, July 14th); supply and delivery f.o.b. port of shipment of 12,000 swan-necked galvanised steel bolts and 27,200 arm bolts (Wellington, July 21st). Egyptian Ministry of Public Works, Mechanical and Electrical Department : Supply, delivery, and erection of a complete steam and hot water boiler plant for the Kasr el Eini Hospital at Cairo (Cairo, June 8th).

Copper and Tin.

At the beginning of this week there was a revival in activity in the copper market after a period of poor trading and steadily receding prices. The low level to which values had sunk stimulated interest on the part of consumers, and a fair amount of buying developed. On the other hand, the manufacturers of finished copper products report that the demand is still quiet. The appearance, however, of the full copper statistics relating to the world outside America which had been withheld owing to the German refusal to provide particulars, helped to restore some confidence to the market. It is now believed that the attitude of the German copper trade was due to the changes resulting from the annexation of Austria, and that when the upset to the industry which this occasioned had been overcome, the figures were made available. On the whole, the complete statistics provided a favourable impression, as they showed that the foreign stocks of refined copper were 185,916 short tons, or 11,156 tons less than in March. On the other hand, the world stocks had increased by 1328 tons to 541,580 tons, and the rise in the American stocks was 12,880 tons. The world's total consumption was estimated at 161,261 tons, compared with 159,000 tons in March. It has been expected for some time that the current price of copper would result in mines closing down, so that little surprise has been occasioned by the announcement that the Anaconda Company will cease production at two of its properties for a time. This, again, had a favourable influence upon the market, and indicated that supplies may be in process of being adjusted to the demand. Attention has been drawn to the increase in the exports of copper from the United States in April, which rose to 35,073 tons from 22,307 tons in March. The London standard market, which has been rather sensitive to political news, improved this week and apparently speculators are again beginning to take some interest in the metal. Rhodesian mines continue to ship copper to this country, with the result that the contango has widened. . . . The tin market has shared in the improvement which has overtaken most of the non-ferrous metal markets this week, and prices have recovered some of the ground recently lost. Trading, however, has not been on a very substantial scale, as there has been a general tendency to wait for definite information regarding the Buffer Pool. This became available on June 1st when the Colonial Office announced that the referendum had resulted in a vote of approximately two to one in favour of the Pool. The European vote was 57 p.c. for and 43 p.c. against and the Chinese vote 76 p.c. for and 24 p.c. against. In forwarding the results the Malay States stress the importance of disinterested management of the Buffer stock. So far as Malay and Nigeria are concerned it has been decided to accept the proposal in principle subject to the negotiation of a satisfactory detailed scheme. The American demand continues poor, and business with the Continent has also been restricted to small parcels.

Lead and Spelter.

Although there seems to be a fairly good undertone in the lead market, trading conditions have been rather irregular. Consumers have apparently covered their requirements for some time ahead, and for the time being are showing little interest in new purchases. On the other hand, the producers are inclined to take advantage of any show of activity in the market to offer metal with some freedom. There is still a certain amount of nervousness in evidence regarding the situation in Mexico. On many previous occasions internal troubles have interrupted supplies of lead from that country, and not unnaturally the market is somewhat apprehensive lest history should repeat itself. Consumers are less impressed by these considerations than by the fact that stocks appear to be increasing, and that apart from any disturbance of the character indicated they should be able to obtain as much prompt metal as they require for some time to come. On the whole, the demand is well maintained, but there are signs here and there that a seasonal decline in business in some classes of lead products is taking place. News from the Continent indicates also that rather quieter conditions rule in most of the lead-consuming industries; but this is a movement which usually develops at this time of the year. According to American figures, the stocks of refined lead in the United States at the end of April totalled 156,715 tons, compared with 143,511 tons at the end of March. In April the production increased to 39,391 tons, whilst deliveries declined to 25,952 tons. . . . At the lower levels to which spelter prices dropped as a result of the Czechoslovakian crisis, a certain amount of speculative buying made its appearance, which developed with the improvement which set in in most of the non-ferrous metal markets this week. When the price stiffened consumers also showed more interest. It has been said for some time past that users of spelter have been content to let their stocks run down and cover only prompt needs, so that an upward movement should bring out a fair amount of buying. On the other hand, there is no evidence of any decline in the quantities offered, and this has checked any tendency for prices to advance too quickly. News from the Continent and from the United States indicates that these markets are quiet.

Non-ferrous Metal Average Prices.

Conditions approaching a slump ruled at times in the non-ferrous metal markets during May, and it is not surprising therefore that the average prices for the metals dealt in on the London Metal Exchange showed a decline for the second month in succession. In the copper market the average for cash metal was £2 12s. 10d. less than for April, whilst for three months' copper the price was £2 13s. 2d. lower. For electrolytic copper the average showed a decline of £2 12s. 1d., and for wire bars of £2 13s. 1d., the best selected quotation being £2 16s. 8d. below the figure for April. In the tin market also the heavy declines during the month were reflected in a drop in the average for cash tin of £5 18s. 9d., three months' metal being £5 18s. 10d. below the April average. Rather more stable conditions prevailed in the lead market, but the average for metal for shipment during the current month was £1 7s. 4d. lower than in April and for shipment in the third following month £1 4s. 11d. less, the mean declining by £1 6s. 2d. In the spelter market a drop of £1 0s. 11d. was registered in the average quotation for shipment during the current month and in the mean; whilst for shipment in the third following month the price dropped £1 1s. below that for April. The following are the official London Metal Exchange quotations for May :—

STANDARD COPPER	Cash (mean)	£36	14	$2\frac{5}{11}$
	3 months (mean)	£36	19	$0\frac{9}{16}$
	Settlement	£36	14	$2\frac{5}{11}$
ELECTROLYTIC COPPER (mean)		£41	5	$1\frac{1}{11}$
ELECTROLYTIC WIRE BARS		£41	13	$2\frac{5}{11}$
BEST SELECTED COPPER (mean)		£40	15	10
STANDARD TIN	Cash (mean)	£162	16	$8\frac{5}{11}$
	3 Months (mean)	£163	8	9
	Settlement	£162	16	$9\frac{5}{11}$
LEAD	For shipment the current month	£14	4	$2\frac{5}{11}$
	For shipment the third following month	£14	7	$6\frac{11}{14}$
	Mean	£14	5	$10\frac{3}{16}$
	Settlement	£14	4	$1\frac{5}{11}$
SPELTER	For shiment the current month	£12	13	$7\frac{7}{11}$
	For shipment the third following month	£12	17	$4\frac{7}{11}$
	Mean	£12	15	$6\frac{3}{16}$
	Settlement	£12	13	$4\frac{6}{11}$

Current Prices for Metals and Fuels.

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from associated British Steelmakers. †Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-.

	Home.	Export.
	(D/d Teesside Area.)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	6 12 6	—
„ No. 1	6 13 0	7 7 6
Cleveland—		
No. 1	5 11 6	6 2 6
No. 3 G.M.B.	5 9 0	6 0 0
No. 4 Foundry	5 10 0	5 19 0
Basic	5 0 0	—
MIDLANDS—		
Staffs—	*(Delivered to Black Country Station.)*	
North Staffs. Foundry	5 11 0	—
„ „ Forge	5 6 0	—
Basic	5 0 0 to £5 5 0	—
Northampton—		
Foundry No. 3	5 8 6	—
Forge	5 5 6	—
Derbyshire—		
No. 3 Foundry	5 11 0	—
Forge	5 8 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	6 13 0	—
No. 1 Foundry, ditto	6 0 6	—
No. 3 Foundry, ditto	5 18 0	—
Basic, d/d	5 7 6	—
N.W. COAST— Hematite Mixed Nos.	6 13 0 d/d Glasgow 6 18 6 „ Sheffield 7 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS AND YORKS—	£ s. d.	£ s. d.
Crown Bars	13 5 0	—
Best Bars	13 15 0	—
MIDLANDS—		
Crown Bars	13 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	11 12 6	—
No. 4 Quality	12 2 6	—
SCOTLAND—		
Crown Bars	13 5 0	13 5 0
Best	13 15 0	13 15 0
N.E. COAST—		
Crown Bars	13 5 0	13 5 0
Best Bars	13 15 0	13 15 0
Double Best Bars	14 5 0	14 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	13 17 6	—

STEEL.

	*Home.	†Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	11 3 0	10 12 6
Tees	12 3 0	11 12 6
Joists	11 3 0	10 12 6
Channels	11 8 0	10 17 6
Rounds, 3in. and up	12 3 0	11 12 6
„ under 3in.	12 15 6‡	11 0 0
Flats, under 5in.	12 15 6‡	11 0 0
Plates, ¼in. (basis)	11 13 0	11 0 0
„ ⅜in.	11 18 0	11 5 0
„ ½in.	12 3 0	11 10 0
„ ⅝in.	12 8 0	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¼in.	12 3 0	12 2 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 10 0
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Plates, ¼in. (basis)	11 8 0	11 0 0
„ ⅜in.	11 13 0	11 5 0
„ ½in.	11 18 0	11 10 0
„ ⅝in.	12 3 0	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¼in.	11 18 0	12 2 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¼in. (basis)	11 10 6	11 0 0
„ ⅜in.	11 15 6	11 5 0
„ ½in.	12 0 6	11 10 0
„ ⅝in.	12 5 6	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¼in.	12 0 6	12 2 6

STEEL (*continued*).

	*Home.	†Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	11 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¼in. (basis)	11 8 0	11 0 0
„ ⅜in.	11 13 0	11 5 0
„ ½in.	11 18 0	11 10 0
„ ⅝in.	12 3 0	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¼in.	11 18 0	12 2 6
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¼in. (basis)	11 10 6	11 0 0
„ ⅜in.	11 15 6	11 5 6
„ ½in.	12 0 6	11 10 0
„ ⅝in.	12 5 6	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G)	12 10 0	12 2 6

IRELAND—F.O.Q.—	BELFAST.	REST OF IRELAND.
	£ s. d.	£ s. d.
Angles	11 5 6	11 8 0
Tees	12 5 6	12 8 0
Joists	11 5 6	11 15 6
Channels	11 10 6	11 13 0
Rounds, 3in. and up	12 5 6	12 8 0
„ under 3in.	12 18 0‡	13 0 6
Plates, ¼in. (basis)	11 13 0	11 15 6
⅜in.	11 18 0	12 0 6
½in.	12 3 0	12 5 6
⅝in.	12 10 0	12 10 0
Un. ⅜in. to ½in. incl.	12 3 0	12 5 6

‡ *Rounds and Flats tested quality; untested 9/- less.*

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. f.o.b. £ s. d.
11-G. and 12-G., d/d	14 15 0	11-G. to 14-G 12 15 0
13-G., d/d	15 2 6	
14-G. to 20-G., d/d	15 10 0	15-G. to 20-G 13 0 0
21-G. to 24-G., d/d	15 15 0	21-G. to 24-G 13 5 0
25-G. and 26-G., d/d	16 10 0	25 and 26-G. 14 0 0

South Africa, Rhodesia, Canada £14 f.o.b. basis Irish Free State, £15 15s., f.o.q., four-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10 cwt., £2 per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.—

Home.	£ s. d.
4-ton lots and up	18 10 0
2-ton to 4-ton lots	18 17 6
Under 2 tons	20 2 6

Export; India, £18 15s. c.i.f.; Irish Free State, £18 10s. f.o.q.; General, £16 15s. f.o.b., 24-G. basis.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 20/3 to 21/6.

Tin-plate Bars, d/d Welsh Works, £7 15s.

Billets. 100-ton lots and over, 35 to 100 tons, 5/- extra: less than 35 tons, 10/- extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 17 6
„ „ „ tested	8 7 6
Basic (0·33% to 0·41% C.)	8 12 6
„ Medium (0·42 to 0·60% C.)	9 2 6
„ Hard (0·61% to 0·85% C.)	9 12 6
„ „ (0·88% to 0·99% C.)	10 2 6
„ „ (over 0·99% C.)	10 12 6
Rails. Heavy, 500-ton lots, f.o.t.	10 2 6
„ Light, f.o.t.	9 2 6

FERRO ALLOYS.

	Per Ton.	Per Unit
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro Tungsten	4/8 per lb. (nominal)	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 5 0	7/6
„ „ 6 p.c. to 8 p.c.	£24 0 0	7/6
„ „ 8 p.c. to 10 p.c.	£24 0 0	7/6
„ „ Max. 2 p.c. carbon	£36 0 0	11/-
„ „ „ 1 p.c. carbon	£38 5 0	11/-
„ „ „ 0·50 p.c. carbon	£41 0 0	12/-
„ „ „ carbon-free	1/- per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£18 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 0 0 scale 6/- p.u.	
„ Vanadium	14/- per lb.	
„ Molybdenum	4/9 per lb.; 5/- forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton	
Cobalt	8/6 to 9/6 per lb.	

NON-FERROUS METALS.

(Official Prices, June 1st.)

COPPER—	
Cash	£32 18 9 to £33 0 0
Three Months	£33 3 9 to £33 5 0
Electrolytic	£37 5 0 to £38 0 0
Best Selected Ingots, d/d Birmingham	£37 15 0
Sheets, Hot Rolled	£68 0 0
	Home. Export.
Tubes, Solid Drawn (basis)	11¾d. 11¾d.
„ Brazed (basis)	12d. 12d.
BRASS—	
Ingots, 70/30, d/d Birmingham	£32 10 0
	Home. Export.
Tubes, Solid Drawn, 2/1 Alloy	10¾d. 10¾d.
„ Brazed	12¾d. 12¾d.
TIN—	
Cash	£163 0 0 to £163 5 0
Three Months	£163 15 0 to £164 0 0
SPELTER—	
Cash	£11 17 6 to £12 0 0
Three Months	£12 2 6 to £12 3 9
LEAD—	
Cash	£13 6 3 to £13 7 6
Three Months	£13 8 9 to £13 10 0
Aluminium Ingots (British)	£100 to £105

FUELS.

SCOTLAND.

LANARKSHIRE—	
(f.o.b. Grangemouth)—	Export
Navigation Unscreened	19/- to 19/6
Hamilton Ell	17/6
Splints	20/-
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	17/6
Unscreened Navigation	18/- to 19/-
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	17/-
Secondary Steam	16/6

ENGLAND.

SOUTH YORKSHIRE, HULL—	
B.S.Y. Hards	21/6 to 22/-
Steam Screened	19/- to 19/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/6 to 19/-
„ Second	18/-
„ Best Small	17/6
Unscreened	18/- to 19/-
DURHAM—	
Best Gas	21/- to 21/6
Foundry Coke	29/- to 35/-

SHEFFIELD—	Inland.
Best Hand-picked Branch	28/- to 29/6 —
South Yorkshire	25/6 to 27/- —
Seconds	22/- to 24/- —

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	24/- to 24/6
Best Seconds	24/-
Best Dry Large	23/6 to 24/-
Ordinaries	23/6 to 24/-
Bunker Smalls	18/- to 19/-
Cargo Smalls	17/- to 18/-
Dry Nuts	24/6 to 26/-
Foundry Coke	42/6 to 57/6
Furnace Coke	30/- to 35/-
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	38/- to 41/-
Machine-made Cobbles	41/- to 51/-
Nuts	40/- to 50/-
Beans	33/- to 38/6
Peas	26/- to 29/6
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	20/- to 25/-

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon
Furnace Oil (0·950 gravity)	3½d
Diesel Oil	4½d.

French Engineering Notes.

(From our own Correspondent in Paris.)

New Industrial Decrees.

THE second series of decrees in favour of economic activity and industrial expansion number fifty-three, which may be taken as covering as many different phases of the problem as the Government has undertaken to solve, and while there is some question whether this machinery can be put in movement smoothly and efficiently the country will nevertheless wait with patience to see how it will work. The idea of the Government's plan is to give an impulsion to activity by co-ordinating, increasing, and financing a vast scheme of public works, whereby industry will respond more readily to reforms which aim at an expansion of production and foreign trade. The programme provides for an expenditure of 11,000 million francs on public works until the end of 1940. The State will contribute more than one half of that amount, and the remainder will be provided by public and private bodies, which will be accorded facilities for raising money by public loans. This expenditure is accompanied by a disposal of private capital, notably a sum of 3000 million francs by the electricity companies which will push forward their hydro-electric and other schemes. The amount of private capital to be devoted to production undertakings is expected to be considerable. The Government's plans provide for road construction on a large scale, and a continuance of works on the radial roads leading out of Paris which are to join the international roads that are part of the scheme for facilitating motor traffic between Paris and the different frontiers. All over the country the plans for rural equipment are to be completed, such as water and electricity supply, and ample provision is made for the building trades, which are a necessary factor in the activity of the iron and steel industries. The financing of all these undertakings, and many others, is only possible under conditions of national stability and confidence, and there is every indication that the country is prepared to support the Government in its efforts to revive the national economy.

Working Hours.

The decree for a reorganisation of working hours confirms what had been previously said in these notes about the Government's intention to adapt the forty hours' week to the necessities of industry. The tolerances allowed by the law have been stretched to the uttermost, but the Government is unable to go beyond the law, and while loosening the bonds on employers it has not removed them. The principle of the forty hours' week is maintained. Practically, however, the hours are spread over the year to a total of 2000, with an extension of from 75 to 150 hours to provide for exceptional pressure of work. For work on national defence there is no limit to the number of additional hours the men may be called upon to put in when necessary. In cases where works and factories run regularly all the year round employers have the option of six days with fewer daily hours or eight hours for the full week by staggering the men from one week to another. The unions can no longer make the five days' week compulsory. The short week depends upon the convenience of employers. They have also the right to the additional hours fixed by law, as well as the making up for hours lost through temporary stoppages or for other reasons, except strikes and lock outs. On the other hand, when the work is of an intermittent or seasonable character, and there is little doing during slack periods, the hours lost can be added to the legal number of hours allotted for the following twelve months, so that the weekly hours in busy seasons may be raised to forty-eight and even, in certain special cases, to sixty. There is consequently a wide range of adaptability with the idea of ensuring industrial activity in all circumstances. Employers have so far been unable to take advantage of tolerances allowed by the forty hours' law because the General Labour Confederation seized upon it to impose a rigid five days' week, and the formalities required to obtain permission to profit from the reservations were too complicated to tempt employers to take advantage of them. The formalities have now been greatly simplified. In the case of works temporarily closing down, the factory inspector is informed of the date and duration, and the hours lost are added to the coming yearly total, while if an industry has to deal with an exceptional pressure of work, permission for additional hours is granted by the Minister of Labour, either for a local branch or for the entire industry, as the case may be. The additional hours are regarded as overtime with extra pay, and in the event of men being discharged when the pressure eases off those who are normally on the pay roll have a priority to be taken on again if more labour is needed within six months. The value of these concessions is discounted by the manner in which employers are tied to a system that leaves them with no freedom to act individually, nor are they sure of being able to deal with unforeseen contingencies that arise through industrial fluctuations. While employers have the right to additional hours they are only accorded after acceptance by labour unions.

Foreign Trade.

There is to be another series of decrees to complete an economic reorganisation which is of so comprehensive character that the Government deserves credit for accomplishing a heavy task in a very short time, and while there is an impression that the rapidity with which it has been done may reveal lapses when putting the plan into execution, the decisions, for the most part, appear logical. The export trade is encouraged by relieving it of the production tax, and the State provides a large measure of credit, as well as security against default or irregularities in foreign payments. An innovation to encourage the shipping trade is the creation of zones on the coast and in inland waterway areas outside the Customs jurisdiction where international markets will be established. These neutral zones are not free ports, but international commercial centres for an interchange of goods, without the necessity of paying import duties before the goods are sold.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

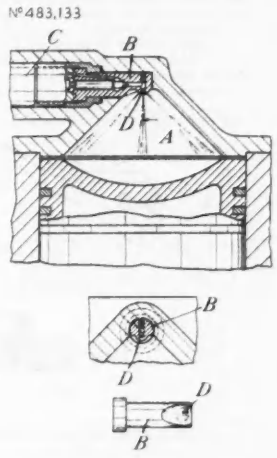
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton-buildings, Chancery-lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

483,133. September 17th, 1937.—FUEL INJECTION NOZZLES, Robert Bosch Aktiengesellschaft, 4, Militärstrasse, Stuttgart, Germany.

The present invention relates to fluid controlled fuel injection nozzles for internal combustion engines of the type wherein several injection apertures are provided in the nozzle member to produce a group of fuel jets, the axis of symmetry of which lies substantially at right angles to the axis of the nozzle member. The cylinder cover contains a conical space A and in its apex is a radial bore into which is inserted a nozzle member B, which



is secured by means of a screw cap to a nozzle holder C. A spherically arched tip D is formed in a recess in the cylindrical part of the nozzle member. The axis of symmetry of the tip extends at right angles to the longitudinal axis of the nozzle member and co-axially with the axis of the cylinder. Five injection apertures are bored radially in the tip or boss. The fuel reaching the injection apertures in the tip D is injected into A in diverging streams, which are so relatively inclined that they substantially conform as a whole to the conicity of the space.—*April 12th*, 1938.

BATTERIES AND ACCUMULATORS.

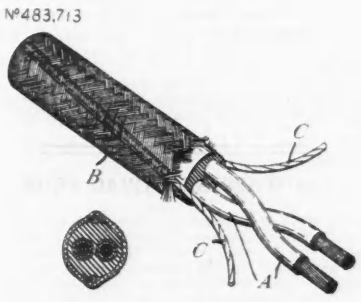
483,562. October 16th, 1936.—SECONDARY ELECTRIC BATTERIES, Alfred Noel Hazlehurst, of "Four Winds," Iver Heath, Bucks.

The use of grids formed from a lead-mercury alloy in accordance with the invention enables batteries to be constructed which give off no gas during standing or discharge and which can be hermetically sealed except during charge. A form of secondary battery in accordance with the invention has pasted positive plates comprising grids formed from lead-mercury alloys containing approximately 97 per cent. lead and 3 per cent. mercury and means, such as unvented plugs, are provided whereby the battery may be hermetically sealed. Both positive and negative plates are pasted with litharge and nothing is added to the paste which would generate gas, either by attack of the acid or the working of the cell. The use of carbon in the battery, either as an expander for the negative paste or for any other reason, is avoided. The negative plates may be of pure lead.—*April 19th*, 1938.

TRANSMISSION OF POWER.

483,713. October 23rd, 1936.—FLEXIBLE ELECTRIC CABLES, Callender's Cable and Construction Company, Ltd., of Hamilton House, Victoria Embankment, London, E.C.4; and Leslie Hart, of the company's address.

Flexible electric cables are in some cases provided with a textile cord (or cords) embodied in the cable serving as means for resisting a tension that may be applied to the cable when in service. The cable constructed in accordance with this invention consists of two insulated conductors A laid up helically together and enclosed by an extrusion process in a body of rubber, whereby the cable is built up into circular form. On the outside

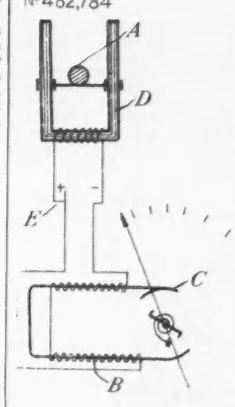


of the body of the cable is applied a non-metallic braid B of woven yarn, which forms a closely fitting covering for the cable, and between this braid and the body of the cable are arranged two textile tension cords C. The tension cords are disposed diametrically opposite one another and are laid helically round the body of the cable with a length of lay which is considerably greater than that of the constituent parts of the braid B and is also greater than the lay of the cable cores. The tension cords are in contact with the outside of the body of the cable and are held in place by the braid, the adherence of the cords to the body of the cable being increased during the final vulcanisation process, which is effected after the application of the braid. The presence of the tension cords beneath the non-metallic braid produces outstanding ridges in the braid. These ridges are useful since they facilitate the location of the tension cords when the end of the cable is prepared for connection to an electrical appliance. These ridges can, however, be obviated or reduced if required by providing suitable grooves in the surface of the body for the reception of the tension cords.—*April 25th*, 1938.

MEASURING AND TESTING INSTRUMENTS.

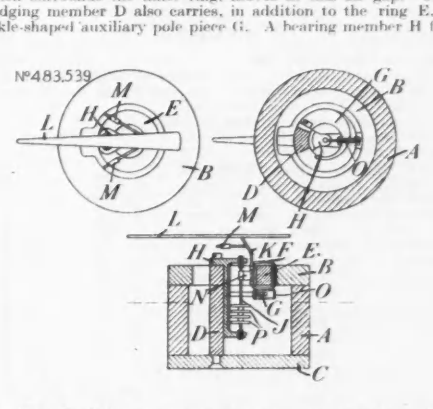
482,784. April 1st, 1937.—MEASURING OR INDICATING TRANSIENT ABNORMAL ELECTRIC ALTERNATING CURRENTS, Ernö Reich, of 16, Vorosmarty—U., Budapest, VII, Hungary, and the General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2.

The object of this invention is to provide a simple instrument which will give directly a reasonably accurate indication or measurement of the value of transient abnormal alternating currents. When the instrument is applied to the conductor A change in the magnetic field produced by current flowing in the conductor induces a current in the coils B, which, in turn, creates a magnetic flux in the plates C, which displaces the armature from its zero position. If a large current impulse passes through the conductor and the circuit through the conductor is subsequently broken, then the plates A, being remanent, will remain magnetised to an extent depending upon the value of the impulse current and the pointer will take up a corresponding position on the scale. When the reading has been taken the plates are demagnetised by any known method. The instrument is best calibrated by marking on the scale the position which the pointer takes up after an impulse of known value has been passed through a conductor to which the instrument is applied. It will be understood that D is a current transformer, which is connected in circuit with a rectifier at E.—*April 5th*, 1938.



483,539. September 29th, 1937.—MOVING COIL ELECTRIC MEASURING INSTRUMENTS, Siemens und Halske Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

In the construction shown, a hollow cylindrical permanent magnet A is axially magnetised so that the poles are at the ends, an outer pole piece or ring B being mounted on the upper end face. The magnet is supported upon a lower pole plate C, to which is riveted a bridging member D extending upwardly in the axial direction. The bridging member carries an inner pole piece or ring E, which is so shaped and arranged that a uniform air gap extending over an angle of more than 270 deg. is formed between the inner ring E and the outer ring B. A main coil F, which surrounds the inner ring, moves in this air gap. The bridging member D also carries, in addition to the ring E, a sickle-shaped auxiliary pole piece G. A bearing member H for

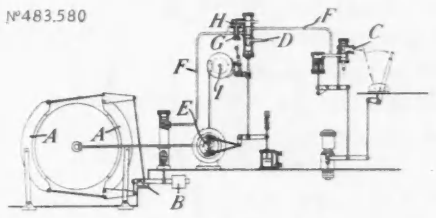


the pivot J of the measuring mechanism is secured to the bridging member, the main coil F, a support K for a pointer L, and counterbalance weights M being connected to the pivot J by a member N. An auxiliary coil O surrounding the auxiliary core G is connected to the main coil F. Springs P are employed as current supply leads to the two moving coils. The pointer is arranged so that, when in the zero position in which it is normally maintained by the springs, the auxiliary coil which is connected, as a control coil, is near the end of the auxiliary core G; that is, in the angular position where the radial width of the core G is a minimum. Therefore, as the deflection increases with increasing current in the main coil F, which is connected as a measuring coil, the field of the control coil and consequently the control force are strengthened, so that the deflection corresponds in the manner known to the quotient of the currents in the measuring coil and the control coil.—*April 21st*, 1938.

MINING MACHINERY.

483,580. October 22nd, 1936.—IMPROVEMENTS IN BRAKING DEVICES FOR WINDERS, General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2; and Hugh Herbert Foster, Messrs. Fraser and Chalmers Engineering Works, Erith, Kent; and Frank Leonard Whitmore, of "Newland," Burkitt-road, Woodbridge, Suffolk.

The brake shoes A A of a mine winder are controlled in the



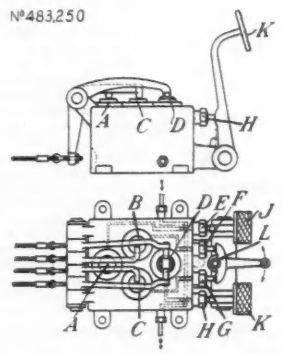
usual manner by the weights B, which are held off by fluid pressure controlled by the driver from the pilot valve C. The auxiliary valve D actuated by the governor E prevents too rapid deceleration by the driver by disconnecting the pipe F and connecting it to a supply of pressure fluid and thereby releasing the brakes. The improvement in accordance with the invention is

in the mechanism for controlling the auxiliary valve D and also in its construction. D is a slide valve, modified so that it can act as an emergency brake valve. For this purpose an extension G is arranged to connect the pipe F to exhaust *viâ* an adjustable needle valve H. The needle valve H is connected to an arm of a bell-crank lever, which is also connected to the operating rod of the slide valve D by a lost motion connection. The bell-crank is operated by a cam I as the end of the wind is approached and positively opens H to its full extent and moves the slide valve D to restore the connection with the pilot valve C, if this has not already been done. The brakes are thus under the control of the driver at the end of the wind and, if the emergency valve D has also been operated, rapid application of the brakes is automatically effected through the wide open needle valve. The coupling of the operating rod of the valve D to the mechanism of the governor is such that no damage can occur to the operating mechanism as a result of a bearing seizure or in an emergency application of the brake.—*April 22nd*, 1938.

MOTOR CARS AND ROAD TRAFFIC.

483,250. January 12th, 1937.—SERVO-CONTROL DEVICES FOR ENDLESS TRACK VEHICLES, Závody Tatra Akciová Spolecnost Pro Stavbu Automobilu a Železnicních Vozu, Kartouzska 200, Prague-Smichov, Czecho-Slovakia.

This invention relates to a servo-control method of steering vehicles of the type driven by endless tracks arranged on both sides of the vehicle, the tracks of which are driven at different speeds when manœuvring. The housing contains four cylinders, A, B, C, D, actuated by oil pressure through the valves E, F, G, H respectively. The valves E and H are actuated by the pedals

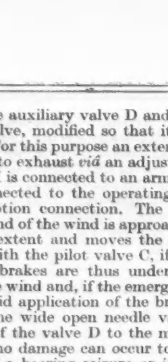


J K and the valves F G by lever L. As may be seen, each cylinder controls one of a series of cables or rods through a lever. If, for example, the pedal J is depressed the piston A raises the two levers on top of it and these, through the corresponding transmissions, disengage the two driving clutches of the endless track driving shafts. To travel round a corner the lever L is moved raising the piston in B or C as the case may be. These pistons lift the control levers to the driving clutch and brake pertaining to the endless track on that side of the vehicle.—*April 14th*, 1938.

BUILDING.

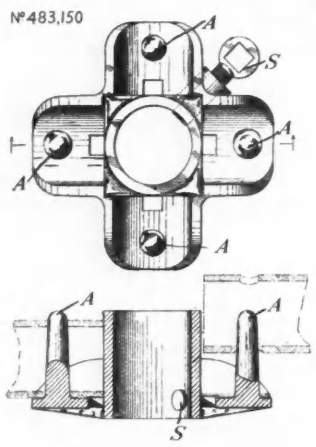
481,604. September 16th, 1936.—BUILT-UP HOLLOW STRUCTURES, O. D. Henry, 12, Wigmore-street, London, W.1.

This invention relates to bricks used in the construction of built-up hollow structures such as cylindrical silos, storage bins, tanks, &c. The bricks are formed with a rib extending down the full depth of one of the vertical end faces and with a groove extending down the opposite end face, the rib and groove being shaped as a segment of a circle so that the groove receives, as a close fit, the rib of an adjacent brick. Preferably the grooved edge is increased in thickness by a bulbous or other formation to increase the strength. Any suitable reinforcement may be incorporated in the brick, and means is provided for encircling the built-up structure to keep the bricks interlocked. The bulbs on the bricks are arranged to project on the outside and may be horizontally notched to receive the encircling bands.—*March 15th*, 1938.



483,150. October 12th, 1936.—SCAFFOLDING, Scaffolding (Great Britain), Ltd., and David Henry Jones, 344–360, South Lambeth-road, London, S.W.8.

This is a system of scaffolding in which structures are built up of standard length tubes assembled together in angular relationship to each other. The supporting member shown is attached to the vertical tube by the set screw S. It comprises



a collar formed with four flanges at right angles to each other, and each flange is curved to correspond with the diameter of the tube to be supported. Each of these flanges carries a vertical taper stud A. The collar is also formed with vertical side faces adapted to act as stops for the end of the tubes. Each tube has a tapered hole at the end to conform with the studs A of the supporting collar.—*April 12th*, 1938.

MISCELLANEOUS.

482,857. July 9th, 1937.—MANUFACTURE OF DUST CORES, Siemens und Halske Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

This invention relates to the manufacture of dust cores for magnetic inductances of the type wherein fine particles of magnetic material are mixed with insulating or binding material, so that, as far as possible, each magnetic particle is separated from its neighbour by insulating material. The process consists of subjecting a mixture of magnetic particles and the insulating or binding material to the action of vibrations of supersonic frequency. A frequency between 200 and 2000 kilocycles per second is suitable. The material mixed with the magnetic particles may be one of the usual insulating powders, or a liquid solution from which the solvent is subsequently evaporated, or it may be a plastic material. It is possible in manufacture to use viscous insulating materials, which it would be almost impossible to employ if the mixing were done by the usual tumbling or grinding process. Alternatively, particles may first be coated with insulating material by oxidation in the usual manner, and then mixed with a binder, the main purpose of which is to cause the particles to cohere rather than to insulate them. The supersonic vibrations are preferably generated by a piezo-electric crystal. The materials to be mixed are placed in a container immersed in paraffin oil in which the oscillator is also immersed. The oil serves to transmit the vibrations to the mixture. A power of several hundred watts is suitable for the oscillator.—*April 6th*, 1938.

483,089. October 13th, 1936.—AN IMPROVED FASTENING DEVICE, Oliver Edwin Simmonds, Shell-Mex House, Strand, London; and Simmonds Development Corporation, Ltd., 18, Essex-street, Strand, London.

The improved fastening device according to this invention comprises a plate on which a nut is secured in such a manner that the nut may move in one or more directions relatively to the plate to a limited extent, but cannot rotate relatively to the

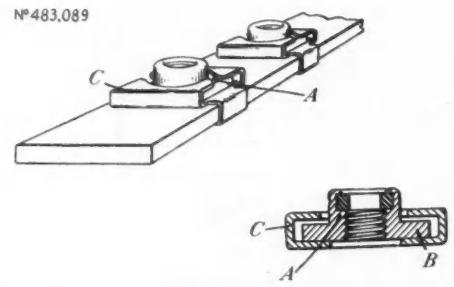
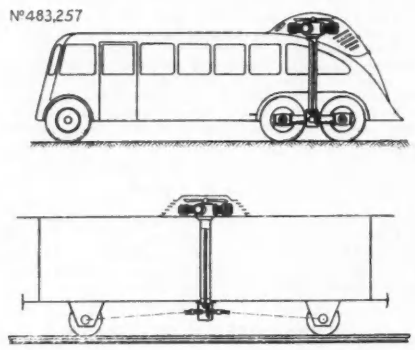


plate. The plate is adapted to be secured to a structural part by rivets, bolts, or by spot welding. The nut A is provided with a flange B, which is inserted within the channel formed by the flanges on the plate C and is retained therein by the inwardly turned edge portions of the flanges. The flange B on the nut is square, as shown, or of such other shape that the nut cannot rotate relatively to the plate, whilst the flanges on the plate are so spaced apart that the nut can move laterally to a limited extent. The drawing shows one method of fixing the nuts to a structural member.—*April 12th*, 1938.

483,257. May 7th, 1937.—MOTOR-PROPELLED VEHICLES, Závody Tatra Akciová Spolecnost Pro Stavbu Automobilu a Zeleznicních Vozu, Kartouzska 200, Prague-Smichov, Czecho-Slovakia.

The object of the invention is to provide a suitable arrange-



ment of the engine of large passenger vehicles where use is made of radial cylinder engines. The engine is arranged above the roof of the vehicle, the drive to the undercarriage or gear-box is transmitted by a vertical shaft. Two different constructional forms of the invention are illustrated as examples.—*April 14th*, 1938.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

THE ENGLISH ELECTRIC COMPANY has received from Transport Vehicles (Daimler), Ltd., for the Bradford Corporation, a repeat order for ten double-deck all-metal bus bodies.

LAUNCHES AND TRIAL TRIPS.

UMGENI, steamship; built by Swan, Hunter and Wigham Richardsons, Ltd., to the order of Bullard, King and Co., Ltd.; dimensions, length 468ft., breadth 61ft. 3in., depth 35ft. 6in.; to carry 8000 tons. Engines, triple-expansion, working in conjunction with exhaust turbines on the Bauer-Wach system, pressure 225 lb. per square inch; trial trip, May 20th.

SCOTTISH PRINCE, motorship; built by the Blythswood Shipbuilding Company, Ltd., to the order of the Rio Cape Line, Ltd.; dimensions, length 430ft., breadth 56ft., depth 35ft. 6in.; to carry 9000 tons. Engines, opposed-piston two-stroke airless injection, cylinders 520 mm. diameter by 2080 mm. stroke; constructed by Barclay, Curle and Co., Ltd.; trial trip, May 24th.

TRIADIC, motorship; built by Lithgows, Ltd., to the order of the British Phosphate Commissioners; dimensions, length 435ft., breadth 60ft., depth 37ft. Engines, four-stroke single-acting; constructed by Kincaid and Co.; trial trip, May 25th.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INST. OF MECHANICAL ENGINEERS. Summer meeting at Cardiff.

MONDAY, JUNE 6TH TO SATURDAY, JUNE 11TH.

INST. OF PETROLEUM TECHNOLOGISTS.—Conference on Oil Shale and Cannel Coal at Glasgow.

WEDNESDAY, JUNE 8TH, TO SUNDAY, JUNE 12TH.

INST. OF LOCOMOTIVE ENGINEERS.—Summer Meeting in Scotland.

SATURDAY, JUNE 11TH TO WEDNESDAY, JUNE 15TH.

INST. OF AUTOMOBILE ENGINEERS.—Summer Meeting at Buxton.

TUESDAY, JUNE 14TH, TO FRIDAY, JUNE 17TH.

INST. OF BRITISH FOUNDRYMEN.—Annual Conference, at Bradford.

NEWCOMEN SOC.—Summer meeting in the Lake District.

WEDNESDAY, JUNE 15TH.

INST. OF CIVIL ENGINEERS.—Great George-street, Westminster, S.W.1. Conversazione. 7.45 p.m.

TUESDAY, JUNE 21ST, TO FRIDAY, JUNE 24TH.

INTERNATIONAL ENGINEERING CONGRESS.—At Glasgow.

TUESDAY, JUNE 21ST TO SATURDAY, JUNE 25TH.

BRITISH WATERWORKS ASSOC.—Twenty-seventh annual general meeting and conference at Plymouth.

TUESDAY, JUNE 21ST.

INST. OF CIVIL ENGINEERS: PORTSMOUTH, SOUTHAMPTON AND DISTRICT ASSOC.—Visit to the Winchester by-pass road works (County of Southampton).

THURSDAY, JUNE 26TH.

RAILWAY CLUB.—Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Great Eastern Section Suburban Services of the L.N.E. Railway," B. R. White. 7.30 p.m.

MONDAY, JULY 4TH, TO FRIDAY, JULY 8TH.

INST. OF ELECTRICAL ENGINEERS.—Summer Meeting at South Midland Centre.

THURSDAY, AUG. 25TH TO FRIDAY, SEPT. 2ND.

WORLD POWER CONFERENCE.—Vienna sectional meeting.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

CLIFTON AND WADDELL, Johnstone, near Glasgow, have appointed Mr. P. G. Stirling as their London representative, with a London address at Salisbury Square House, E.C.4.

STEPHENSON CLARKE AND ASSOCIATED COMPANIES, Ltd., of 4, St. Dunstan's-alley, London, E.C.3, announce that the Rt. Hon. Lord Hyndley has been elected chairman of the company in succession to Sir Stephenson H. Kent, K.C.B., who retired recently.

CALLENDER'S CABLE AND CONSTRUCTION COMPANY, Ltd., is opening on June 1st a new sales office and stores at 131, Rose-street, Edinburgh, 2. The new office will be under the charge of Mr. J. H. Dinwoodie. The address of the company's contracts office, 18, Grosvenor-street, Edinburgh, 12, remains unchanged.

MR. TOM N. WOOF has been appointed London district manager for Burton, Griffiths and Co., Ltd., Birmingham. Mr. Woof was associated with Alfred Herbert, Ltd., for a number of years and was until recently manager for Scotland, prior to which he was in charge of their South American business with headquarters in Buenos Aires.

E. G. PHILLIPS, consulting engineer, Queen's Chambers, King-street, Nottingham, informs us that as from June 7th the designation and address of the firm will be E. G. Phillips, Son and Norfolk, consulting engineers, Arskus House, Annesley-grove, Nottingham. The present telephone numbers will remain unaltered, *i.e.*, 42095 and 42096.

JOHN I. THORNYCROFT AND CO., Ltd., inform us that they have appointed Major R. R. Seward, M. I. Mech. E., as manager of the marine department of their London office, in succession to Commander R. Leyland. Major Seward has been associated with the firm for many years, and during a considerable period was managing director of its subsidiary company, Thornycroft do Brasil.

FERRANTI, Ltd., have recently entered into arrangements with Wild-Barfield Electric Furnaces, Ltd., Elecfurn Works, North-road, Holloway, N.7, and their associated company, G.W.B. Electric Furnaces, Ltd., Belgrove House, Belgrove-street, W.C.1, whereby these two companies have the sole right for the supply of Ferranti moving coil voltage regulators when fitted with the Ferranti temperature voltage relay control for furnace work.

BABCOCK AND WILCOX, Ltd., of Babcock House, Farringdon-street, London, E.C.4, announce that they have acquired from the Allen-Sherman-Hoff Company, of Philadelphia, the exclusive world rights, with the exception of the U.S.A. and Canada, for the manufacture and sale of the well-known "Hydro-Jet" system of ash and dust handling, which rights have hitherto been held by the Ash Company (London), Ltd. The Ash Company (London), Ltd., will complete all contracts already taken by it or obtained by it up till June 30th, 1938. Mr. P. B. Silk, who will continue as a director of the Ash Company (London), Ltd., will join their staff at June 30th, and will be appointed as manager of the crane and conveyor department on the retirement of Mr. A. Lennox.

CATALOGUES.

RUSTON AND HORNSBY, Ltd., Lincoln.—Publication 7703, describing the firm's oil-engined locomotives and their capabilities.

A. REYROLLE AND CO., Ltd., Hebburn-on-Tyne.—Pamphlet No. 1034, dealing with the standardisation of British circuit breakers.

JAMES HOWDEN AND CO. (LAND), Ltd., Caxton House, S.W.1.—A brochure on heavy-duty fans for boiler plant and industrial processes.

SIMPLEX ELECTRIC COMPANY, Ltd., Broadwell-road, Oldbury, Birmingham.—List W.H. 1621, on "Creda" storage and immersion-types electric water heaters; a general catalogue of the firm's products, and list SW 1626 of "Simplex" switch and fuse gear.

Printed on thin paper for overseas circulation.

The Engineer

LONDON, FRIDAY JUNE 10, 1938.

PUBLIC NOTICES.

Air Ministry.

APPLICATIONS are INVITED for CIVILIAN POST of DRAUGHTSMEN, GRADE II, at various Royal Air Force Stations. Candidates should have had a good technical training, Engineering Workshop and Drawing Office experience.

Salary: Up to 82s. a week, depending on qualifications and experience. Promotion to Draughtsman, Grade I (£220-10-£260-12-£330 per annum), is governed by merit as and when vacancies arise.

Grade II appointments are non-pensionable. Draughtsmen, Grade I, and above are eligible for consideration for appointment to pensionable posts in the event of vacancies arising on the permanent establishment.

Application should be made on a form to be obtained (quoting reference No. B.505) from the UNDER SECRETARY OF STATE, Air Ministry, S.2.D. (S.205), Adastral House, Kingsway, W.C.2, to whom it should be returned. 4447

Air Ministry.

APPLICATIONS are INVITED for a POST as ASSISTANT MASTER in the Apprentices' School at the Royal Aircraft Establishment, South Farnborough, Hants.

The successful candidate will be required to Teach Machine Drawing, Mechanics, and Mathematics to the standard of the Ordinary National Certificate, and Applied Thermodynamics for first-year Higher National Certificate.

Candidates should possess a Degree (Hons. preferred) in Engineering, Science, or Mathematics, and should preferably be experienced in teaching the subjects referred to above.

The scale of salary is £234 by £15-£480 a year.

Application should be made on a form to be obtained (quoting reference A.68) from the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it should be returned not later than the 24th June, 1938. 4796

Air Ministry.

DIRECTORATE OF TECHNICAL DEVELOPMENT.

VACANCIES for DRAUGHTSMEN, GRADES I and II, at the Royal Aircraft Establishment, South Farnborough, Hants:—

REF. 710 C.—DRAUGHTSMAN, GRADE I, for work in connection with the Design of Aircraft Electrical Equipment.

REF. 66 C.—DRAUGHTSMAN, GRADE I, for Illustrational Work for Technical Publications.

REF. 59 C.—DRAUGHTSMAN, GRADE II, for work in connection with Light Precision Mechanisms.

Candidates should have had good general education and technical training, and experience of a character appropriate to the post applied for.

SALARY SCALES.

Draughtsman, Grade I: £220 a year, rising by annual increments of £10 to £260 (efficiency bar), and thence by £12 to £330 a year. Commencing salary up to £260 a year, according to qualifications and experience.

Draughtsman, Grade II: Up to 82s. a week. Commencing salary according to qualifications and experience.

The appointments are non-pensionable. Entrants to Grade I will be eligible for consideration for appointment to pensionable posts in the event of vacancies arising on the permanent establishment. Promotion from Grade II to Grade I is governed by merit.

Application should be made on a form to be obtained (quoting the appropriate Ref. No.) from the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants, to whom it should be returned not later than 24th June, 1938. 4797

Applications are Invited

for the POST of CHIEF TECHNICAL INSTRUCTOR (Engineering and Building Construction) in the new Government Trade School, Haifa. Candidates, preferably not over 35, should possess suitable technical qualifications, good industrial experience and a minimum of 3 years' teaching experience in Technical or Trade Schools. Duties commence on 1st September, 1938.

The appointment is for 2 years in the first instance. The salary is £445, rising by £15 a year to £550, together with an expatriation allowance of £50 a year, and free furnished quarters and board in return for residential duties.

Further particulars and forms of application can be obtained from the SECRETARY, I.P.R./CA, Board of Education, Whitehall, S.W.1. Candidates resident in Scotland should apply to the SECRETARY, Scottish Education Department, Whitehall, S.W.1. Closing date, Monday, 27th June, 1938. 4779

Department of Scientific and Industrial Research.

JUNIOR SCIENTIFIC OFFICER REQUIRED at the Building Research Station, Garston, near Watford, for work in connection with Technical Inquiries relating to Building Design and Construction. Candidates should have a good Scientific Training, as represented by an Honours Degree or equivalent qualification, and must have had experience with an Architect or Builder. Salary scale, £275 by annual increments of £18 to £347 for men, and £275 by £12 to £320 for women, with provision under the Federated Superannuation System for Universities after two years' service. Entry will not necessarily be at the minimum of the scale in the case of candidates with exceptional experience. The salary scale for the grade of Scientific Officer, promotion to which is by merit, is for men, £400-£18-£454-£25-£580 (efficiency bar)-£25-£680, and for women, £350-£18-£464 (efficiency bar)-£25-£580.

Application must be made not later than Monday, 27th June, 1938, on a form to be obtained on request (by postcard, quoting reference J. 38/6), from the ESTABLISHMENT OFFICER, Department of Scientific and Industrial Research, 16, Old Queen-street, Westminster, S.W.1. 4778

Required by H.M. Office of Works.

STRUCTURAL ENGINEERING DRAUGHTSMEN, experienced in Designing and Detailing Structures, Foundations, &c., in REINFORCED CONCRETE or with experience in Designing and Detailing Steel-framed Buildings and other STRUCTURAL STEELWORK.

Salaries for the above vacancies from £4 to £6 10s. per week, according to experience.

Also a limited number of ENGINEERING DRAUGHTSMEN who combine experience of both Reinforced Concrete and Steelwork, at salaries up to £7 10s. per week.

Apply, giving age, particulars of education, training, and experience to—

THE CHIEF ARCHITECT (Ref. G.W.Struct.),
Room 131A, Fourth Floor,
H.M. Office of Works,
Storey's-gate,
Westminster, S.W.1.

4648

The Engineer

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The Design and Operation of a Modern Blooming Mill—No. II. (P. 658)
(W. F. CARTWRIGHT.) THE ENGINEER, 10 - 6 - 38.

Institution of Mechanical Engineers—Cardiff Summer Meeting No. II. (P. 652)
THE ENGINEER, 10 - 6 - 38.

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PUBLIC NOTICES.

Crown Agents for the Colonies.

COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POSTS:—

M/5856.—ENGINEER REQUIRED by the Government of Nigeria for the Public Works Department (Temporary Staff) for two tours of 12 to 24 months each, with possible extension and eligibility for transfer to the permanent and pensionable establishment. Fixed salary ranging from £500 to £720 a year, according to qualifications and experience; a higher salary may be reached if transferred to the permanent establishment. Free passages and quarters and liberal leave on full salary. Candidates, age 23-40, must hold a University Degree in Civil Engineering, or have passed Sections A and B of the A.M.I.C.E. Examination, or the Associateship in Civil Engineering of the City and Guilds Institute, and have had practical experience in Waterworks Investigation and Construction, Drainage Work, or some phase of Hydraulics.

M/5939.—ASSISTANT ENGINEER REQUIRED by the Government of Trinidad for the Public Works Department for 3 years with possible permanency. Salary, Trinidad dollars 2400-120-2880 a year (Trinidad dollars 4.80 equals £1). Free passages and, if married, for wife and family not exceeding four persons. Leave on full salary. Candidates, age 30-40, must be Corporate Members of the Institution of Civil Engineers, or hold an Engineering Degree recognised as granting exemption from Sections A and B of the A.M.I.C.E. Examination. They must have had recent and considerable experience in Building and Road Construction, and extensive knowledge and experience of the Designing of Buildings.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting the reference number against the appointment for which application is made. 4806

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

PUBLIC NOTICES.

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Applicants should have had not less than three years' workshop experience. Age 21 years to 30 years. Preference given to ex-Service men, other things being equal. Pay up to 82s. per week, according to ability and experience. Posts are non-pensionable, but, subject to suitable qualifications, entrants are eligible for consideration for promotion and for appointment to the pensionable establishment should vacancies arise.

Application forms obtainable by postcard from CHIEF SUPERINTENDENT of ORDNANCE FACTORIES (Advt. No. 218), Royal Arsenal, Woolwich, S.E.18. 4593

University College of South Wales and Monmouthshire.

COLEG PRIFATHROFAOL DEHEUDIR CYMRU A MYNWY.

The Council of the College invites APPLICATIONS for the APPOINTMENT of ASSISTANT LECTURER and DEMONSTRATOR in CIVIL ENGINEERING. The commencing salary will be £300 per annum.

Further particulars may be obtained from the undersigned, by whom three copies of applications and testimonials must be received not later than Thursday, June 30th, 1938.

LOUIS S. THOMAS,
Registrar.

University College,
Cardiff. 4807

University of Birmingham.

APPOINTMENT OF LECTURER IN DEPARTMENT OF CIVIL ENGINEERING.

APPLICATIONS are INVITED for the POST of LECTURER in CIVIL ENGINEERING. Commencing stipend at the rate of £400 per annum. Duties to begin October 1st, 1938. Candidates must hold a University Degree and have had practical experience, preferably in Structural Steel or Concrete. They must be prepared to undertake research. Four copies of application, with testimonials or references, must be sent on or before June 24th to the undersigned, from whom further particulars may be obtained.

C. G. BURTON,
Secretary.

June, 1938. 4750

PUBLIC NOTICES.

Manchester Municipal College of Technology.

Principal:
B. MOUAT JONES, D.S.O., M.A. (Oxford).

DEGREE COURSES IN TECHNOLOGY.

The PROSPECTUS of UNIVERSITY COURSES gives PARTICULARS of the COURSES leading to the Manchester University Degrees (B.Sc. Tech., M.Sc. Tech., and Ph.D.), and Certificates in the Faculty of Technology in the following Departments:—

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ELECTRICAL ENGINEERING.
(Professor John Hollingworth, M.A., D.Sc., M.Sc. Tech., F.C.G.I., M.I.E.E.)
MUNICIPAL ENGINEERING.
(E. J. Cornish, M.Sc., A.M. Inst. C.E., A.M. I. Mech. E., A.M. I. Struct. E., M.R. San. I.)
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University of London. King's College.

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J. K. CATTERSON-SMITH, M.Eng., M.I.E.E.

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Head of Department:—
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Head of Department: W. A. SCOBLE, D.Sc., M.I. Mech. E., Assoc. M. Inst. C.E.

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Particulars of the appointments and forms of application may be obtained from the SECRETARY, on receipt of a stamped addressed envelope.

Closing date, 17th June. 4737

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CLASSIFIED ADVERTISEMENTS CLOSE FOR

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The Engineer

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*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next due, June 24th.

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The charges for Classified Advertisements is 1/- per line up to one inch—minimum chage 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

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PUBLIC NOTICES.

County Borough of Brighton.

LAUGHTON LODGE COLONY FOR MENTAL DEFECTIVES.

The Corporation invites TENDERS for ONE 20-KILOWATT DIESEL-ALTERNATOR, 400 volts, 3-phase, 50 cycles per second, with AUTOMATIC STARTING for the Laughton Lodge Colony, Laughton, Sussex.

Form of Tender, specification, and general conditions of contract, may be obtained upon application to Mr. W. N. C. Clinch, Engineer and Manager, Brighton Corporation Electricity Undertaking, Electric House, Castle-square, Brighton, 1, on payment of a deposit of £2 2s. (which will be refunded only on the return of all documents and the receipt of a bona fide Tender not subsequently withdrawn).

Tenders and all documents (which must be in plain, sealed envelopes not bearing any name or mark indicating the sender), endorsed "Tender for Diesel-Alternator," must be delivered to the undersigned not later than 12 Noon on Wednesday, 22nd June, 1938.

No Tender will be considered which does not comply with these conditions.

The Council does not bind itself to accept the lowest or any Tender.

J. G. DREW,
Town Clerk.

Town Hall,
Brighton, 1,
7th June, 1938. 4799

County Borough of Brighton.

ELECTRICITY UNDERTAKING.

The Corporation invites TENDERS for the LAGGING of STEAM RECEIVERS, VALVES, and STEAM and FEED PIPES in connection with Boiler and Turbine Plant at the Southwick Power Station.

Form of Tender, specification, drawing, and general conditions of contract may be obtained upon application to Mr. W. N. C. Clinch, Engineer and Manager, Brighton Corporation Electricity Undertaking, Electric House, Castle-square, Brighton, 1, on payment of a deposit of £1 1s. (which will be refunded only on the return of all documents and the receipt of a bona fide Tender not subsequently withdrawn).

Tenders and all documents (which must be in plain, sealed envelopes not bearing any name or mark indicating the sender), endorsed "Tender for Lagging," must be delivered to the undersigned not later than Monday, 27th June, 1938.

No Tender will be considered which does not comply with these conditions.

The Council does not bind itself to accept the lowest of any Tender.

J. G. DREW,
Town Clerk.

Town Hall,
Brighton, 1,
7th June, 1938. 4798

County Borough of Croydon.

ELECTRICITY DEPARTMENT.
COAL-HANDLING AND STORAGE PLANT.

TENDERS are INVITED for the SUPPLY, DELIVERY, and ERECTION of COAL-HANDLING and STORAGE PLANT at the Electricity Works, Factory-lane, Croydon.

Specifications and forms of Tender may be obtained from the Chief Engineer and General Manager, "Electric House," 38, High-street, Croydon, on payment of £1 1s., returnable on receipt of a bona fide Tender.

Tenders, in plain sealed envelopes, which must not bear any name or mark indicating the sender, endorsed "Tender for Coal-handling and Storage Plant," must reach me not later than Noon on Monday, July 4th, 1938, and will only be received subject to the Draft Contract, including the I.E.E. Model General Conditions, deposited at my office, which may be inspected during office hours.

Plans may be inspected at the Electricity Works, Factory-lane, Croydon.

The Council will not be bound to accept the lowest or any Tender.

E. TABERNER,
Town Clerk.

Town Hall,
Croydon,
June 7th, 1938. 4800

County Mental Hospital,

LANCASTER.
STEAM-DRIVEN GENERATORS.

TENDERS are INVITED from bona fide Manufacturers only for the SUPPLY and ERECTION of THREE 75-kW STEAM ENGINES, DIRECT-CURRENT GENERATORS, and CONTROL PANELS.

Tenders, in plain envelopes, endorsed "Engines," and addressed to the Chairman of the Committee, must be delivered not later than Thursday, June 30th, 1938.

Specifications and further particulars can be obtained from the Engineer on application to the undersigned.

A. V. WALE,
Clerk and Steward.

County Mental Hospital,
Lancaster,
3rd June, 1938. 4776

Metropolitan Water Board.

HAMPTON WORKS.—MAINS.

The Metropolitan Water Board invite TENDERS for the LAYING of STEEL MAINS and CONNECTIONS of various diameters up to 66in., together with the CONSTRUCTION of about 250 LINEAL YARDS of STEEL-LINED CONCRETE CONDUITS of 60in. and 78in. diameter at their Hampton Works, Lower Sunbury-road, Hampton-on-Thames, in the County of Middlesex.

The drawings and contract documents may be inspected without charge at the offices of the Board, Chief Engineer's Department (Room 201).

Forms of Tender, conditions of contract, specification, and bills of quantities, together with drawings and a spare copy of the bills of quantities, may be obtained on and after Monday, 13th June, 1938, from the Chief Engineer, on production of an official receipt for £10, which sum must be deposited with the Comptroller to the Board and which will be returned on receipt of a bona fide Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the bills of quantities, which may be retained by the tenderer). Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Mains, Hampton Works," must be delivered at the offices of the Board (Room 122) not later than Twelve o'clock Noon on Tuesday, 5th July, 1938.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C.1,
28th May, 1938. 4725

PUBLIC NOTICES.

County Mental Hospital,

WHITTINGHAM,
NEAR PRESTON, LANCASHIRE.
NURSES' HOME.
TO HEATING CONTRACTORS.

The Committee of Visitors for Whittingham Mental Hospital invites TENDERS (in connection with the Erection of a Nurses' Home) for the SUPPLY and INSTALLATION of ADDITIONAL ENGINEERING PLANT, consisting of Heating and Hot and Cold Water Supply Systems, to the designs of Messrs. Ernest Griffiths and Son, MM. I. Mech. E., The Temple, Dale-street, Liverpool, to whom application must be made for the necessary particulars, consisting of general conditions, conditions of contract, and tendering instructions, forms of Tender, specifications and plans, which will be forwarded on payment of a deposit of £5, which will be refunded on receipt of a bona fide Tender.

Tenders must be received not later than 9 a.m. on Thursday, 23rd June, 1938, in plain, sealed envelopes, addressed to the Clerk and Steward, County Mental Hospital, Whittingham, near Preston, Lancashire, and endorsed "Tender for Engineering Work, Nurses' Home," and must not bear any name or mark indicating the sender.

The Committee does not bind itself to accept the lowest or any Tender, and the Tender accepted by the Committee will be accepted conditionally on the approval of the necessary Statutory and other Authorities being obtained.

Dated this 4th day of June, 1938.

(Sgd.) LEONARD COTMAN,
Clerk to the Committee of Visitors.

County Mental Hospital,
Whittingham, near Preston. 4792

London County Council.

TENDERS INVITED for the SUPPLY and ERECTION at North Woolwich Pumping Station, Albert-road, E.16, of FIVE SEWAGE and STORM-WATER PUMPING SETS. Two comprising Oil Engines of 300 B.H.P., with Centrifugal or mixed-flow Pumps: Two comprising Electric Motors (one of 125 B.H.P. and one of 65 B.H.P.), with similar Pumps; and One comprising a 30 B.H.P. Oil Engine and a 25 B.H.P. Electric Motor, with a Three-throw Ram pump; also AUXILIARY MACHINERY, PIPING, and VALVES.

Specification, form of Tender, &c., obtainable from Chief Engineer on and after Monday, 13th June, 1938, upon payment of £5 by crossed cheque or order payable to London County Council. (NOTE.—CASH WILL NOT BE ACCEPTED.)

Amount returnable only if bona fide Tender is submitted and not subsequently withdrawn. Particulars of work obtainable on personal application and contract documents may be inspected before payment of fee.

Remittances by post should be addressed to the Chief Engineer (B), County Hall, Westminster, S.E.1. Personal inquiries at Room 549 D.

Contractors will be bound to observe the provisions of a fair wages clause, terms of which are set out fully in the instructions for Tender, form of contract, and the "London County Council Gazette."

No Tender received by CLERK OF THE COUNCIL at County Hall after 4 p.m. on Monday, 18th July, will be considered. 4781

Metropolitan Water Board.

TENDERS FOR THE SUPPLY OF STORES, &c.

The Metropolitan Water Board invite TENDERS for the SUPPLY of the undermentioned STORES, &c., for the period of 12 months commencing 1st August, 1938:—

Contract No.
2 .. Brushes, Brooms, and Handles.
5 .. Cotton Waste, Wipers, Hemp, Rope, &c.
10 .. Lead Pipe, Solder.
13 .. Oilman's Sundries.
14 .. Packings, Rubber Goods, Hose, and Belting.
15 .. Paints, Varnishes, Linseed Oil, Turpentine, &c.
24 .. Electric Lamps.

Tenders must be submitted on the official forms, which may be obtained from the Chief Engineer by personal application at the Offices of the Board (Room 171), or upon forwarding a stamped, addressed envelope (large).

Applicants should refer to the number of the Tender for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board," and endorsed in the manner indicated in the form of Tender, must be delivered at the Offices of the Board (Room 122), not later than 12 o'clock Noon on Monday, 27th June, 1938.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board:
173, Rosebery-avenue, E.C.1,
3rd June, 1938. 4782

Metropolitan Water Board.

HAMPTON WORKS.—ASH BUNKERS.

The Metropolitan Water Board invite TENDERS for the CONSTRUCTION of REINFORCED CONCRETE ASH BUNKERS, approximately 35ft. by 16ft. by 30ft. high, and a MAKE-UP WATER TANK, approximately 19ft. by 16ft. by 9ft. high, together with a CONCRETE ACCESS ROAD, approximately 60 yards long, at their Hampton Works, Lower Sunbury-road, Hampton-on-Thames, in the County of Middlesex.

The drawings and contract documents may be inspected without charge at the offices of the Board, Chief Engineer's Department (Room 201).

Forms of Tender, conditions of contract, specification, and bills of quantities, together with drawings and a spare copy of the bills of quantities, may be obtained on and after Monday, 13th June, 1938, from the Chief Engineer on production of an official receipt for £10, which sum must be deposited with the Comptroller to the Board and which will be returned on receipt of a bona fide Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the bills of quantities, which may be retained by the tenderer). Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Ash Bunkers, Hampton Works," must be delivered at the offices of the Board (Room 122) not later than Twelve o'clock Noon on Tuesday, 5th July, 1938.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C.1,
28th May, 1938. 4726

PUBLIC NOTICES.

County Mental Hospital,

LANCASTER.
STEAM MAINS.

TENDERS are INVITED from bona fide Manufacturers only for the SUPPLY and ERECTION of STEEL STEAM MAINS, HANGERS, VALVES, TRAPS, &c.

Tenders, in plain envelopes, endorsed "Steam Mains," and addressed to the Chairman of the Committee, must be delivered not later than Thursday, June 30th, 1938.

Specifications, further particulars, and permission to examine the routes can be obtained from the Engineer on application to the undersigned.

A. V. WALE,
Clerk and Steward.

County Mental Hospital,
Lancaster,
3rd June, 1938. 4777

City of Durban.

APPOINTMENT OF DEPUTY CITY AND WATER ENGINEER.

APPLICATIONS are INVITED for the POSITION of DEPUTY CITY and WATER ENGINEER for the City of Durban, Natal, South Africa. The grade for the position is £1500-£37 10s.-£1736-E, subject to the Council's Scheme of Defiation of Salaries and Wages. The appointment will be in terms of the Council's General Conditions of Service and Leave Regulations, and the commencing salary will be at the minimum of the grade.

Applicants must be under the age of 45 years.

The applicant must be a Corporate Member of the Institution of Civil Engineers, or possess a Degree in Civil Engineering.

The Departmental activities coming under the control of the City and Water Engineer at present include:

PUBLIC WORKS, embracing Roads, Reinforced Concrete and Structural Steel Construction, Storm Water Drainage, Sewerage, Housing, Surveys, Town Planning, Beach Restoration, and General Development.

PARKS AND GARDENS, entailing Lay-out and Control of all Parks, Gardens, and Open Spaces.

BEACH MANAGEMENT, which includes Control of Bathing and General Pleasure Amenities.

STREET CLEANING AND CONSERVANCY, the executive side of Public Health Arrangements dealing with Street Cleaning, Night Soil and Rubbish Removals and Cemeteries.

WATERWORKS, including the Administration of all Works and Estates pertaining to Water Supply.

The successful applicant will be required to undergo a medical examination by a nominee of the Council.

Applications, stating age, qualifications and experience in full, and accompanied by COPIES of not more than three testimonials and supporting documentary evidence of qualifications and satisfactory state of health, must reach the office of the Town Clerk, Durban, South Africa, not later than Friday, 15th July, 1938.

Personal canvassing for the appointment is prohibited and proof thereof will disqualify a candidate, vide Council's Standing Order No. 1.

E. B. SCOTT,
Town Clerk.

Town Clerk's Office,
Municipal Buildings,
Durban,
11th May, 1938. 4650

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Technical Education and Culture.

IN his presidential address, which was delivered at a conference arranged by the Association of Teachers in Technical Schools, and held in Leeds on Monday, June 6th, Mr. A. C. R. Ritchie said that the Association believed that it was not yet too late for the nations to get together in a sane and orderly atmosphere, so that they might work together for the common good of their people, and that the wonders of scientific discovery and inventive genius might at last be directed towards human happiness, instead of being prostituted to the destruction of modern civilisation. He particularly stressed the point that, because social ideas moved so slowly, and a minority of people prostituted the work of scientists and technologists, blame should not be put in the wrong quarter. Gunpowder might well be used for blasting tunnel-ways to make intercommunication easy, or it might be used for the devastation of cities and human life. If there were those who used it vilely and mischieviously, it was their ideas which should be attacked and rectified, and not the real blessings of technology which should be delayed. The humanities, as they had been so long interpreted, had not prevented the mischief from which we suffered. It was the belief of technologists that their work might lead to humanities broader and nobler than the world had ever yet known. There were some who still regarded technical education as an uncultured thing, and something which was narrowly vocational in all that it did. The Association had no fear of the word "vocational," and it was its belief that within the framework of vocational education it was possible to build up a new "culture." The Association had always held that ideal, and it had helped it to accomplish much. By remaining true to that ideal and by striving constantly for its achievement the Association would, he was confident, accomplish still more in the future.

A Supplementary Naval Estimate.

ON Thursday, June 2nd, a Supplementary Naval Estimate of £2,410,500 was issued, which provides £1,773,500 for the work on the new naval construction programme which is to be carried out during the current financial year, and £637,000 for additional services. The additions to the Fleet which are mentioned under further new construction include two battleships, seven cruisers, one aircraft carrier, and a seaplane carrier, the "Albatross," which is to be purchased from the Government of Australia; three submarines, a destroyer depôt ship, a submarine depôt ship, a Fleet Air Arm supply and repair ship, three minelayers, two gunboats, seven motor boats, three general service lighters, and a baggage lighter, besides a number of miscellaneous craft. All the large ships are to be built by contract. The amount to be spent this year on each of the battleships is £19,530, on each of the four cruisers £15,020, and on each of the other three cruisers £27,710. On the aircraft carrier the sum of £61,080 is to be spent, and the sum of £92,120 on the seaplane carrier "Albatross." The additional amount provided for contract work is £1,713,300 and the amount now to be spent on shipbuilding repairs, alteration, maintenance, &c., during 1938 is £56,479,440, a net increase of £1,484,700. In a memorandum which accompanies the Supplementary Estimate the First Lord of the Admiralty, Mr. Duff Cooper, mentions that in a statement in the original Naval Estimates for 1938 he explained that they contained nothing on account of the new construction programme for 1938 and that a Supplementary Estimate would have to be presented for so much of the work included in that programme as would be carried out during the current financial year.

Reconditioning Maryport Harbour.

IN reply to a question in the House of Commons on Thursday, June 2nd, the Minister of Labour, Mr. Ernest Brown, announced that the Government had given careful consideration to the question of reconditioning the harbour at Maryport, Cumberland, which during recent years, he said, had suffered from the trade depression, so that the existing trade had not enabled the Harbour Commissioners to finance the necessary repairs. In 1935 the Commissioner for Special Areas made a grant towards the dredging of the harbour, but gales had caused silting up and had destroyed some of the harbour works, which made it difficult for ships to use the port. Recently the Harbour Commissioners had appealed to the Commissioner for Special Areas for assistance to put the port into an efficient state at a cost, it was estimated from a report prepared by a firm of consulting engineers, of not less than £75,000. After considering all the circumstances, the Government, Mr. Brown said, had authorised the Commissioner to offer the Harbour Commissioners a sum not exceeding £75,000, in order to carry out the repairs. Of the actual expenditure, one-third would be a free grant and the other two-thirds in the form of a loan. On Friday, June 3rd, it was stated that the Maryport Harbour Commissioners had decided to accept the offer of the Government through the Commissioner for Special Areas; Sir Cyril Kirkpatrick had been appointed the engineer for the works; and that preliminary borings would be proceeded with at once. The offer is some £40,000 below the sum which it is estimated would be required to complete the reconditioning of the harbour, but it will, nevertheless, enable all essential works to be carried out. The plans for a new colliery near to Maryport are now to be proceeded with, and the offer of Government help has been welcomed in the whole of the area surrounding the port.

Air Ministry Industrial Advisers.

ON Saturday, June 4th, it was officially announced by the Air Ministry that the Secretary of State for Air, Sir Kingsley Wood, has decided to set up a panel of Industrial Advisers to the Air Ministry, and that the following had accepted his invitation to serve in this capacity:—Sir Amos Ayre, Chairman of the Shipbuilding Conference and member of the Council of the Institution of Naval Architects; Mr. S. R. Beale, chairman of Guest, Keen and Nettlefolds, Ltd., and a director of several important engineering companies; Mr. J. W. Bowen, formerly the General Secretary of the Union of Post Office Workers and a member of the Cadman Committee; Sir Charles Bruce Gardner, M. I. Mech. E., Executive Chairman of the Society of British Aircraft Constructors and a member of the Air Ministry Committee on Supply in connection with the Royal Air Force Expansion Programme; Lord Cadman, chairman of the Anglo-Iranian Oil Company, Ltd., and the Iraq Petroleum Company, Ltd., who was Chairman of the Committee of Enquiry into Civil Aviation; Lieut.-Colonel J. M. Greenly, M. I. Mech. E., chairman of Babcock and Wilcox, Ltd., and other engineering firms; and Sir Malcolm McAlpine, chairman of Sir Robert McAlpine and Sons, Ltd., the public works contractors. The panel, it is further announced, is to begin its work at once and the first meeting is to take place during the present week.

The Employment Returns.

AN announcement made by the Ministry of Labour on Tuesday, June 7th, states that it is provisionally estimated that at May 16th, 1938, the number of insured persons, aged 16–64, in employment in Great Britain, exclusive of persons within the agricultural scheme, was approximately 11,375,000. This was 15,000 less than the total for April 4th, 1938, and on a comparable basis about 148,000 less than the total for May 24th, 1937. There was a decline in employment between April 4th and May 16th in coal-mining, agriculture, the cotton, iron and steel, tin-plate and motor vehicle industries, and in certain branches of the engineering industry. On the other hand, employment improved in building, public works contracting, the distributive trades, and hotel, boarding-house, and shipping services. At May 16th, 1938, the numbers of unemployed persons on the registers of employment exchanges in Great Britain were 1,314,118 wholly unemployed, 397,529 temporarily stopped, and 67,158 normally in casual employment, making a total of 1,778,805. This was 31,041 more than the number on the registers at April 4th, 1938. This increase was mainly accounted for by temporary stoppages in the coal and cotton industries, and, further, included 10,236 boys and girls owing mainly to the registration of juveniles who reached the school-leaving age at the end of the Easter term. On a comparable basis there was an increase of about 382,000 compared with May 24th, 1937. The total of unemployed workers on May 16th, 1938, included 1,295,652 men, 48,072 boys, 379,943 women, and 55,138 girls.

Aeroplane Engine Factory.

THE Corporation of Crewe has, it is announced, agreed to sell 70 acres of land to Rolls-Royce, Ltd., of Derby, for the construction of a factory for the production of aeroplane engines, on a site which adjoins the main Crewe to Chester railway line. The scheme, we are given to understand, now only awaits the approval of the Air Ministry, after which the work of construction can be begun. The factory is planned to give employment to about 4000 men, and its building and equipment will occupy about six months. The Corporation is to undertake an extensive housing scheme for the factory workers. There is plenty of skilled labour in Crewe and district, and for a number of years past the Crewe Railway Works of the London, Midland and Scottish Railway Company have been on short time. Quite recently about 100 men were discharged from the Crewe workshops, while each year a large number of youths have to leave the works on the completion of their apprenticeship. If, as it is expected, the scheme goes forward, work will be found for about 200 bricklayers on the new factory, while others will find employment on the housing scheme. In order to facilitate the staffing of the proposed factory, the Corporation has further agreed to place the new garage built for the use of its sanitary department at the disposal of Rolls-Royce, Ltd., for the training of workers. The new factory is looked upon by the local authorities as a happy solution of the labour problems with which the town has been faced, particularly those concerned with the absorption of its skilled labour.

Central London Tube Extension.

A FURTHER step towards the completion of the £14,500,000 scheme for the improvement of railway services in North-East London, which is being carried out jointly by the London Passenger Transport Board and the London and North-Eastern Railway, and has already been referred to on more than one occasion in these columns, is about to be taken. Contract drawings are in course of completion, and tenders are shortly to be invited for one of the most important sections of the extension of the Central London tube, from Liverpool-street to Epping, Ongar, and Hainault. Negotiations have been completed between the Ministry of Transport, the local authorities concerned, the London Passenger Transport Board, and the London and North-Eastern Railway Company, and it has been decided that the six existing level crossings are to be abolished and replaced by bridges and subways. In deciding the type of crossing to be employed, a careful census of traffic has been made, and an analysis drawn up which has enabled the best type of crossing, a bridge or a subway with inclined approach ramps, to be selected to suit each individual case. The crossings which are to be replaced are those at Leytonstone Station, Eagle-lane, between Snaresbrook and George-lane stations, George-lane Station, Woodford Station, Buckhurst Hill Station, and Theydon Bois Station. In recent years especially these particular crossings have been a source of inconvenience and congestion for vehicular traffic, and their replacement will be greatly appreciated by all called upon to use the traffic routes which at present are interrupted by them.

A Famous Motor Ship.

THERE is now being broken up at the shipbreaking yard of Thos. W. Ward, Ltd., at Cimba Wharf, Grays, on the Essex shore of the Thames Estuary, the motorship "Dan," which, after nearly a quarter of a century's service with the East Asiatic Company of Denmark as the "Jutlandia," was sold last year to Norwegian owners and is now being scrapped. The old "Jutlandia" was replaced by a new ship of the same name, built by the Nakskov Skibsvaert Akt. and engined by Burmeister and Wain, of Copenhagen, which was commissioned in 1934. The old ship now being broken up is of technical interest as being the first ocean-going twin-screw ship built on the Clyde for propulsion by Diesel engines. She was built and engined by Barclay, Curle and Co., Ltd., and equipped with two sets of eight-cylinder, air-injection oil engines of the Burmeister and Wain four-stroke, single-acting type, having cylinders of 20·87in. diameter with a piston stroke of 28·74in., the total designed output being about 2700 I.H.P. at 135 r.p.m. She was designed for a normal service speed of from 10½ to 11 knots, but on her trial trip over the measured mile at Skelmorlie, as we recorded in an article published in our issue of May 17th, 1912, a mean speed of 12 knots was attained with the engines running at the power and speed mentioned above. The ship had a length of 370ft. between perpendiculars, a beam of 53ft., and a moulded depth of 30ft. She had a measurement of 5300 gross tons, and a deadweight carrying capacity of 7400 tons. Like her sister ships, the "Selandia" and "Fiona," which were built and engined in Denmark, the "Jutlandia" was without funnels, the exhaust from her engines being discharged from her mizzen mast. The absence of funnels was regarded as an important advance at the time, and a few other ships followed the example of the "Jutlandia." But experience soon showed that a funnel was desirable, and few, if any, motorships are now built without one at least. It is obvious that as the power installed increased, the volume of the exhaust gases became so great that some specialised route of large capacity for their discharge to atmosphere became a necessity.

Voltage Regulators.

No. V.

(*Continued from page 611, June 3rd.*)

MANY power station and other generators are controlled by the quick-acting regulator supplied by British Brown Boveri and Co., Ltd. It regulates the voltage by the direct insertion of resistance in the exciter shunt winding and is devoid of vibrating contacts. A motive system, regulating resistance, damping system and elastic recall comprise the main parts. The motive or operating system—

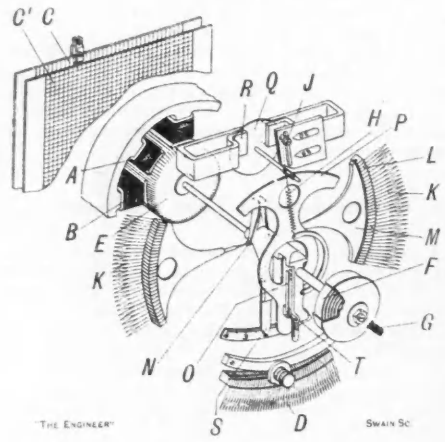


FIG. 31—DETAILS OF BROWN-BOVERI REGULATOR

Figs. 31 and 32—works on the Ferraris principle. A laminated annular core carries two windings A and B. The former is connected to the machine or system to be regulated through the resistances C and D, while the resistance C′ is in the circuit of the second winding B. A phase displacement between the currents in the two windings produces a rotating field, and the resistances also suppress the

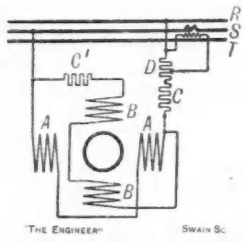


FIG. 32—CONNECTIONS FOR MOTIVE SYSTEM

influence of temperature. The aluminium drum E in the rotating field is subjected to a torque which is transmitted to a steel-tipped operating spindle, pointed at both ends and carried in jewel bearings.

At the front part of the spindle the inner end of a spiral spring F is secured, while the outer end is fastened to the cylindrical housing which contains the spring. By means of the screw G the housing

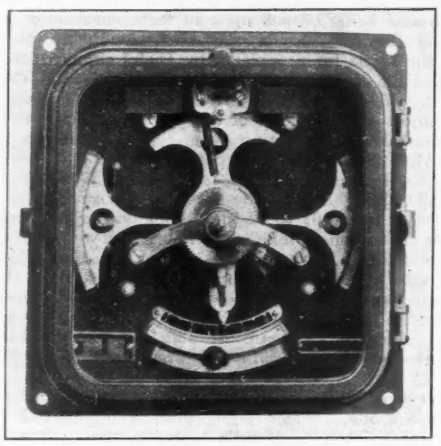


FIG. 33—COMPLETE REGULATOR

can be displaced. An auxiliary spring H connected to the spindle through a bow-shaped lever compensates the effect of the main spring F, so that in whatever position the drum may be in, the resultant torque on the spindle is constant. By means of the main and auxiliary springs the torque set up by the motive system is opposed. Corresponding to each mechanical torque there is a certain electrical torque which balances it and produces a certain fixed voltage at the regulator terminals. If the auxiliary spring is set so that the mechanical torque is constant over the whole range of travel, the motive system will be in equilibrium for a given voltage in any position; but the slightest deviation above or below this voltage will displace the motive system to its extreme position. The regulator maintains the voltage at a constant value independently of the motive system's position.

But by means of the regulating screw J it is possible to loosen the auxiliary spring H so as to compensate only part of the variation in the torque of the

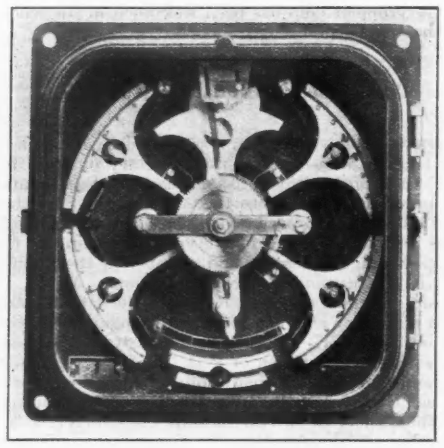


FIG. 34—REGULATOR FOR LARGE ALTERNATOR

main spring, when the voltage corresponding to equilibrium is higher in the position of the motive system corresponding to weak excitation than when the regulating resistance is completely short circuited. The difference between the two voltages which produce equilibrium, expressed in percentage of the average voltage, is termed the "static" of the regulator.

The regulating resistance is composed of resistance coil elements K connected to contact blocks L heavily plated with silver. They are connected in series or groups of two or four—Figs. 33 and 34—and are laid out on arcs of a circle concentric with the axis of the apparatus. A regulator with the casing

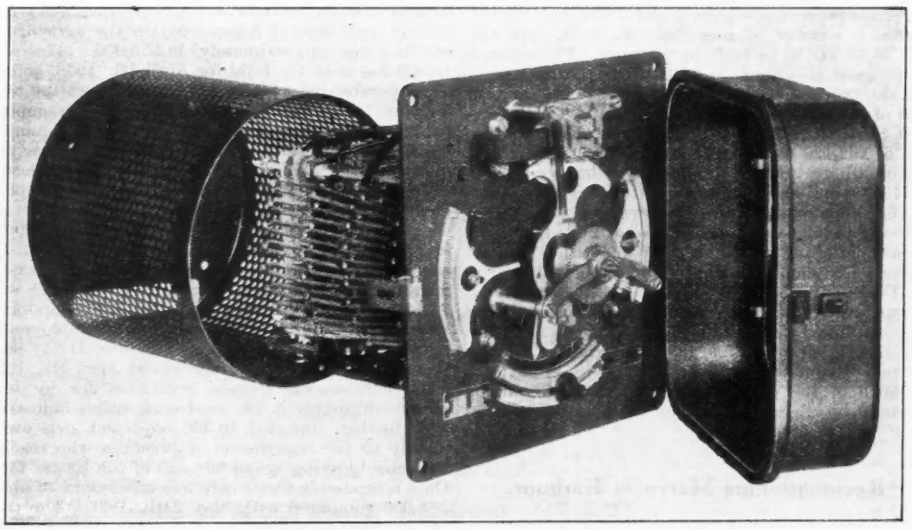


FIG. 35—REGULATOR WITH COVERS REMOVED

removed, exposing the moving parts and resistances is shown in Fig. 35. The sliding contact generally employed in hand-operated rheostats is replaced by contact sectors M, Fig. 31. One of these sectors is provided for each set of contacts, and the sectors roll on the inner surface of the contact blocks, which are grooved to form a track. The steel point of each sector is mounted in a jewelled cup carrier on a spring N, and is guided by the movements of the spindle so as to travel through arcs of a circle and thus cause displacement of the point of contact on the contact blocks. Sufficient pressure is provided by the spring N to ensure good electrical contact, and the reaction of this pressure on the spindle is exactly compensated by the reaction of the sector diametrically opposed to it. Thus friction is practically eliminated and adequate contact pressure ensured. As it requires a very slight force to make the sectors move, displace the point of contact, and change the resistance, an intermediary in the form of a servo motor is unnecessary.

The elastic recall device, which has a great influence on the character of the regulating process, is formed by the recall spring O and the damping system, which follows movements of the regulating system with a certain lag. A toothed segment P driving a damping aluminium disc Q forms the damping system, by the disc moving between the poles of permanent magnets R. By reason of the elastic coupling between the damping system of the spindle regulator, the damping system is very effective for small displacements of the motive system, whilst the drum can rotate to its end position when the load fluctuates violently in order to overcome the magnetic inertia

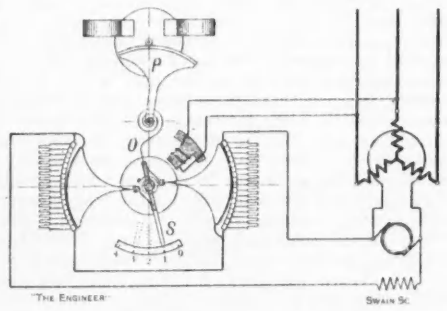


FIG. 36—SIMPLIFIED DIAGRAM OF REGULATOR

of the machine. By means of the recall spring the motive system is brought back before the end of the regulating process to its new position of equilibrium. Normally, the regulators are fitted with single-phase movements, but if required they are provided with open delta-connected or three-phase movements for a three-phase voltage. These special arrangements are usually employed where unbalanced loads are anticipated.

With the aid of Fig. 36, which is purely diagrammatic, the regulating process will be understood. Let it be assumed that the alternator is fully loaded and that it requires excitation at, say, 100 volts to maintain the voltage at its terminals. Under these conditions the contact points of the sectors are situated so that the pointer S is approximately on the position 1 of the scale and, in this position, the resistance is nearly all short-circuited. While the alternator voltage remains at its standard value the torque on the drum will counterbalance that produced by the springs, and the moving system will be in equilibrium. But if, for example, the alternator load is reduced by half, the conditions will immediately change. The alternator voltage rises and with it the torque on the drum, which now exceeds that of the springs and acts on the motive system, causing the pointer S to move to the left. At first the movement is unhindered and rapid, but it causes the spring O between the motive system and damping segment to be tightened and the damping system then follows up slowly. Thus the coil spring produces an opposing torque, which brings the motive system to rest, for example, in the position 3. Meantime the exciter voltage has responded to the contact displacement which has inserted a greater part of the regulating resistance and the pressure is reduced to, say, 50 volts. With a certain time lag attributable to the electro-magnetic inertia of the machine the alternator voltage follows and the electro-magnetic

coupling diminishes proportionally. The counter torque of the tightened recall spring added to that of the main spring is now strong enough to overcome the electro-magnetic torque and produces a return movement of the motive system. Finally equilibrium is established, for example, in position 2 of the indicator, where the exciter voltage is now, say, 70, which is sufficient to maintain the standard alternator voltage under the new load conditions. The simplicity of the recall device and the ease with which it

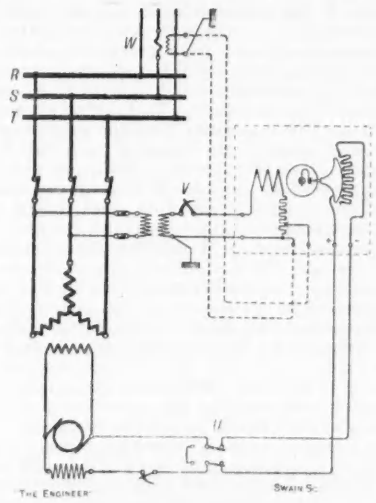


FIG. 37—REGULATOR CONNECTIONS FOR SINGLE ALTERNATOR

can be adjusted by varying the stiffness of the recall spring by means of the screw, as well as by the damping magnets, permit of rapidly setting the regulator for the operating conditions of machines having varied electro-magnetic characteristics.

By means of the resistance C (Figs. 32 and 33) in series with the motive system the service voltage is adjusted, whilst the housing of the main spring F can be revolved to tighten or loosen the main spring and thus alter the voltage for which the regulator is set by

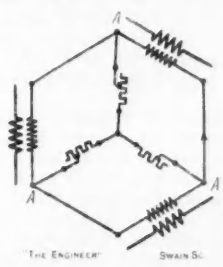


FIG. 38—"POLYGONE" STABILISATION SYSTEM

± 6 per cent. without sensibly affecting the regulator's precision. If the regulator is required to have a still greater range of adjustment, or if frequent changes in the voltage are necessary, an adjustable external resistance is connected in series with the motive system. As the regulator tends to maintain the current strength through its motive system constant, the terminal voltage of the alternator regulated will increase as more resistance is inserted by means of the adjustable external rheostat which is

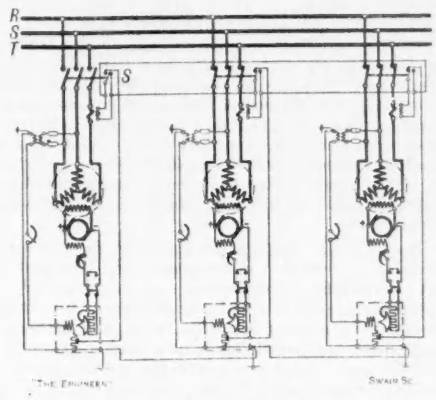


FIG. 39—REGULATOR STABILISED BY "POLYGONE" CONNECTIONS

mounted on the switchboard near the measuring instruments. When it is necessary to compensate the drop in a transmission line the regulator is compounded. The connections for a Brown-Boveri regulator operating on a single alternator are shown in Fig. 37, where the change-over switch U is for changing over from automatic to hand regulation and *vice versâ*. If the regulating conditions to be met do not often have to be modified the adjusting rheostat can also be omitted. W is a current transformer for compounding. As in the case of other voltage regulators, when several alternators run in parallel in the same power station in which there are no heavy load fluctuations and in which the exciters are similar, it is possible to use one regulator which is switched over to the different sets, whilst the wattless current of the machines can be adjusted by hand, as previously described, but a regulator on each machine is generally preferable.

A scheme adopted for making all the alternators running in parallel work at the desired power factor is shown in Fig. 38. As slight inequalities in the setting of the regulators may cause differences in the power factors of the sets, and consequently a considerable exchange of currents, the motive systems are subject to the current delivered by the respective alternators as well as to the voltage in order to attain a wattless load on each alternator proportional to the watt load. The influence

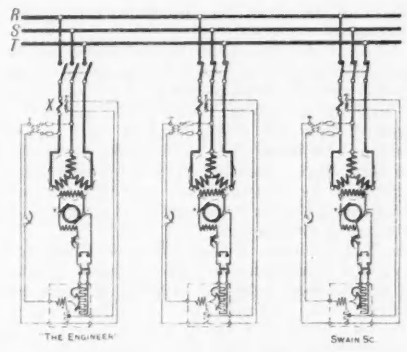


FIG. 40—REGULATORS WITH STATIC CHARACTERISTIC

of the current on the regulator must not interfere with the supply voltage and must only come into play when an unbalanced current distribution occurs, whilst it must cease when equilibrium is established. Stabilisation is attained with the Brown-Boveri regulator either by means of "Polygone" connected regulators, as shown in Fig. 38, or by means of "static-compensated" regulators. In the former case current transformers in a phase not used for the potential transformer are connected in series to form what is termed "the polygone system of stabilisation," and the apexes of the polygon are formed to a central point through adjustable resistances.

If there is even distribution of current the transformers all deliver the same secondary current under the same power factor condition and all the points A of the polygon are at the same potential and no current flows from them towards the central point. But if any alternator begins to work at a power factor differing from that of the other machines, the points A are no longer at the same potential and exchange currents begin to flow over the central point. These currents are superimposed on the other currents of the regulator's motive system and exercise a positive or negative influence on the electro-magnetic torque similar to the effect produced by over-compounding. Thus the regulator contactor sectors are displaced up to the point where even current distribution is again established.

As a result of the phase displacement of the stabilisation current as regards the other current in the winding of the system, inequalities in the watt currents have small influence on the regulator and the wattless current alone influences stabilisation, and it is therefore possible to have alternators working in parallel under very different kilowatt loads. The polygon connections of the regulators will always tend to keep the wattless loads on the alternators equal. The secondary winding of each current transformer is connected to a small rotary change-over switch S (Fig. 39) on the shaft of the alternator's circuit breaker, so that when the machine is switched in or out its current transformer is automatically inserted in or taken out of the "polygone" stabilisation circuit. If there are several sets of bus-bars there must be several "polygone" systems, which entails the use of more or less complicated circuits. For this reason installations of this kind, and often those with only one set of bus-bars, are equipped with compensated regulators, which do not call for connections between the different regulators.

As shown previously, by suitable adjustment of the auxiliary spring the variation of the regulator torque can be compensated partially. An inclined or falling characteristic of the main spring torque is thus created, so that the torque decreases with an increase of excitation. "Static" regulators operating in this way have the defect that when the alternator load increases, the original voltage is not entirely re-established, and *vice versâ*, and if the falling characteristic were not compensated the regulator would be useless. Compensation is, however, obtained by a compensating transformer shown at X in Fig. 40, with its primary winding in the R phase, whilst the voltage system is connected in the phases R and S. It produces a compounding effect which compensates the voltage drop attributable to the "static" characteristic and from no-load to full load the regulator holds the bus-bar voltage constant.

Although it may appear that the same regulating

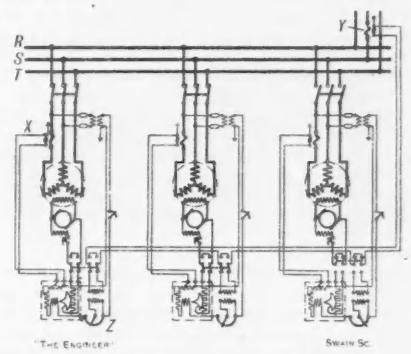


FIG. 42—COMPENSATED AND COMPOUNDED STATIC REGULATORS

effect has been restored to the regulator, in reality there is a fundamental difference between the two modes of regulation, because the effect of the compensating current transformer does not only depend on the strength of the voltage of equilibrium and therefore the excitation, but also on the phase angle between current and voltage. Each static regulator tends to keep the power factor of the alternators working in parallel at an equal value, *i.e.*, to give a distribution of wattless power proportional to the watt power delivered by the various sets.

Compounding can be applied to static as well as astatic regulators stabilised by the "polygone" connection, although on account of simplicity static regulators are nearly always used when compounding is

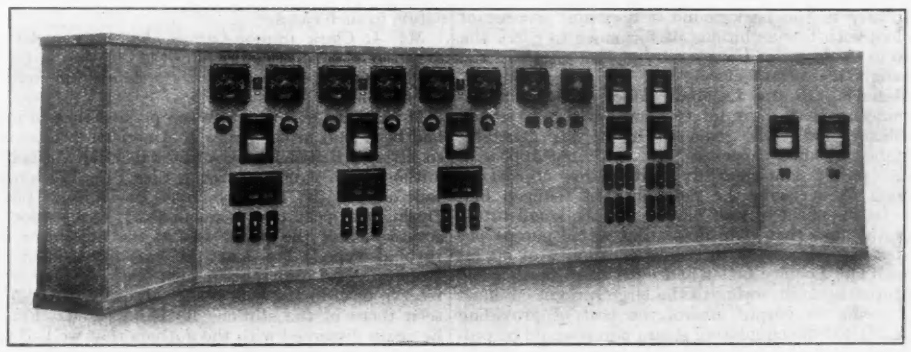


FIG. 41—REGULATORS MOUNTED ON SWITCHBOARD

effected. In Fig. 42 are shown the connections of a power station with static regulators arranged for over compounding. Stabilisation is affected, as in Fig. 40, by the transformer X acting on the ordinary adjusting resistance of the regulator, whilst compounding is secured by the transformer Y acting on the compounding rheostats Z of each regulator. The object of the small auxiliary transformer shown just above Z is to avoid metallic connection between the circuits of the various regulators, and thus to permit earthing the secondary windings of all the current transformers. The four-pole change-over switches indicated on the diagram have three positions, one extreme position corresponding to hand regulation, a medium position for automatic regulation to constant voltage, and a third position giving automatic regulation with over-compounding.

The adjustable rheostats fulfil two objects. Before synchronising they are used for setting the voltage of the alternator and when synchronising has been carried out they allow the wattless current to be distributed among the sets as desired.

The regulator intervenes as soon as the bus-bar voltage has deviated by ±0·5 per cent. from the value for which the apparatus has been set, and in

the case of installations with relatively steady loads the voltage fluctuations can be kept within ±1 per cent. On machines with very pronounced and sudden load fluctuations the voltage may attain ±5 per cent., but they are completely corrected within a few seconds. In the upper part of Fig. 41 are shown a number of Brown-Boveri regulators mounted on a switchboard, the two instruments on the extreme right being a frequency matcher and automatic synchroniser, giving automatic synchronising and coupling.

(To be continued.)

The Incorporated Municipal Electrical Association.

No. III.

(Continued from page 625, June 3rd.)

THE paper by Messrs. Lamb and Baumann on "Present-day Trends in Power Station Practice," summarised in our last number, was discussed at great length on Wednesday morning, May 25th.

Mr. P. J. Robinson, Chief Electrical Engineer, Liverpool, expressed regret, as did a number of other speakers, that so much attention was given in the paper to American practice. He compared the figures of capital cost, fuel and total costs at the Port Washington Station with those being obtained at his own Clarence Dock station, and emphasised that notwithstanding the difference in the design, the results at Clarence Dock compared very favourably indeed with those at Port Washington. For instance, the 200,000 kW of generating and boiler plant, with the necessary buildings and sufficient land for the ultimate development of the Clarence Dock station to 400,000 kW, cost £17·5 per kilowatt installed, and after making a reduction in respect of the site value for the four sets not yet installed this figure fell to £16·7, as against £22 per kilowatt at Port Washington. Again, he pointed out that on the first 100,000 kW of plant at Clarence Dock, with a steam pressure of 400 lb. per square inch, the net fuel cost, including handling and credit for sale of ashes, for 1936 was 0·106d. per unit sent out, compared with 0·08d. at Port Washington, but the figures for the total cost per unit sent out, including capital charges, were 0·202d. at Clarence Dock and 0·268d. at Port Washington. He mentioned, however, that the capital charges at Clarence Dock were very much lower than the 15 per cent. at Port Washington. Assuming the same capital charges, the total costs for the two stations would be exactly the same. Speaking of boiler development, he said that the conditions in this country which called for opening up of turbines for general examination and also the cleaning of boilers at certain intervals gave little scope for the adoption of the one-turbine one-boiler principle here. At the same time he said that too much undeserved publicity was being given to this type of plant, and it was a significant fact that in America in the few cases where plants were erected on this single-unit, high-availability basis, there was invariably hidden modestly in the background a very fine reserve of boilers with less ambitious performance to carry the load in the event of trouble on the plant on which the limelight had been focused!

Referring to the La Mont boiler, he said it was significant that even in Germany where so much publicity had been given to it, it was generally installed in small capacities, and it did not appear in large power stations. It had many objections, among them being the possibility of reduced life, due to the effect of soot blowing on the small tubes, and the fact that two circulating water pumps per boiler were necessary to ensure continuity of operation. The Loeffler boiler had even more undesirable features, because, owing to the large ratio of circulating steam to output steam, the cost of providing standby for the circulating steam pump would be prohibitive and technical difficulties in the way of providing suitable isolating valves and changing over from one pump to another in the case of breakdown would also arise. He considered a reversion to a boiler containing such masses of closely spaced small tubes was a retrogression to be deplored. Referring to welded steam pipes, Mr. Robinson mentioned that in 1936 a pipe line 7in. bore and 2100ft. long, to supply live steam from Clarence Dock to an adjoining manufacturing works, was welded and had neither bolts nor flanges, and it was accepted by the insurance company.

Mr. F. Forrest, Chief Electrical Engineer, Birmingham, said no comment had been made in the paper on the extraordinarily difficult problem of coal-handling plants for large generating stations, and pointed out that the size of large power stations running at high load factors would be governed very largely by the ability of the railways to put the coal into the power station sidings in a regular and continuous flow. Eventually on the Hams Hall site at Birmingham there would be 540,000 kW of plant, in two separate power stations, and 5000 to 6000 tons of coal per day would be required. Remarking that he believed pulverised fuel firing would eventually be the standard method for such large stations, he said there were difficulties in getting the right class of coal, and he was already faced with the necessity of having to crush large coal himself. There was also great difficulty in disposing of the ash from pulverised fuel fired plants.

Captain J. M. Donaldson (Chief Engineer, Metropolitan Electric Power Supply Company) spoke of the high cost per kW of plant installed for apparatus for gas washing in power plants—30s. per kW—and suggested that the installation of such apparatus should not be insisted upon in power stations away from large cities. He also expressed satisfaction with the outdoor type switchgear, although the authors had indicated that in their view most engineers would prefer indoor switchgear.

Mr. F. H. Clough (British Thomson-Houston Company, Ltd.), referring to superposition plant, said that a 10,000-kW turbine was being built in this country for the Detroit Edison Company, which had an initial pressure of 815 lb. per square inch and a temperature of 900 deg. Fah. The turbine would exhaust into the existing plant at 400 lb. pressure and the flow of steam was of the order of 500,000 lb. per hour. These conditions justified the expectancy of good efficiency, but a somewhat complicated valve gear was necessary. After stating that the cost involved in the establishment of the various high-power switchgear testing stations had been justified by the increased knowledge obtained, he pleaded with users to be moderate in their demands for using these stations for demonstration and proving, holding the view that these stations were better employed on valuable research work.

Mr. E. Parry (Electricity Department, Leicester) expressed disappointment that the paper did not give more guidance to power station engineers here as the result of the authors' knowledge of American conditions. Continuing, he expressed the view that a very good case could be made out for much higher steam pressures and temperatures than were generally used in this country at present, and he differed from the authors in that he believed a good case could also be made out here for superimposed plant. The point was that we had some fine stations in this country on admirable sites with a capacity of from 100,000 to 200,000 kW, which would sooner or later have to be extended and superposition should find a useful application in such cases.

Mr. J. Clark (Simon-Carves, Ltd.) discussed the question of natural *versus* forced circulation in boilers and strongly advocated the claims of natural circulation.

Mr. Chittenden, who also complained that so much had been said in the paper of American practice and so little of British and Continental practice, said the authors were wrong in saying that Port Washington was one of the few one-boiler one-turbine plants. During the past two years out of forty stations in America, half the plant was of the one-boiler one-turbine type. He also differed from what Mr. Robinson had said that in such stations there was a reserve of ordinary boilers; at all events he had not seen them in the stations he had visited. Finally, he again disagreed with the authors that we had gone ahead in the matter of temperatures in this country as compared with America, and said that 900 deg. Fah. had been in use there for years and that temperatures were going still higher.

Mr. W. M. Dodds advocated the claims of stoker-fired boilers as against pulverised fuel firing. The use of that method of firing on large boilers in America, he said, was partly due to the industrial depression and partly to the fact that large boilers were in the hands of a few manufacturers who were primarily interested in pulverised firing. He added that up to 1935 the established record of 280 lb. per hour as the maximum amount of steam ever obtained per square foot of total boiler-room floor area was held by the Hudson Avenue stoker-fired boilers, and he had not since heard that that had been exceeded.

There was not time for the authors to reply in detail, but Mr. Baumann explained that the reason why so much attention had been given to American practice in the paper was that the authors had visited many power stations there and been given information freely, whilst it was not easy to get information about Continental stations. As to British practice, it was assumed that engineers here knew all about it. He also mentioned, with regard to Mr. Robinson's comparison of Port Washington and Clarence Dock, that the capital charges in the former case included coal dock, land, and storage for the complete station of some 400,000 kW capacity. The final figure was expected to be 75 dollars per kW instead of the present 100 dollars.

In the afternoon on Wednesday, May 25th, a long discussion took place on the Government's proposals, as set out in the McGowan Report and the White Paper, with regard to the reorganisation of electricity distribution. Last year serious differences of opinion between the Council and the smaller authorities manifested themselves and a separate organisation, known as the Committee of Smaller Municipal Electricity Supply Undertakings, was formed. It has been very active and the country has been divided into areas with Area Committees, the authorities in question paying a special subscription. It was felt that the I.M.E.A. was being largely run by the bigger authorities and that the small authorities were being sacrificed. That action on the part of the smaller authorities gave the impression that there was a split in the ranks of the I.M.E.A., and it has even been said that the I.M.E.A. as a body was losing some of its influence in Government quarters. It is not surprising, therefore, that strong efforts have been made to compose such differences as exist, and the discussion on Wednesday afternoon made it clear that the I.M.E.A. Council is now championing the cause of the smaller authorities in the manner the latter wish. At the same time, there has been a definite refusal to disband the Committee for Smaller Undertakings, but it can be taken that it will work in close co-operation with the Council now, and the meeting in question considerably cleared the air, as did what took place at the private annual general meeting of the Association later in the week.

On Thursday morning, May 26th, a paper was presented by Councillor F. E. Sugden (barrister-at-law) on "Hire-purchase Law and its Application to Municipal Electricity Undertakings." It was prompted by the Bill on this subject sponsored by Miss Ellen Wilkinson, which passed its third reading in the House of Commons on May 6th, and in its present form considerably modifies the powers relating to hire-purchase possessed by electricity supply authorities. However, on the occasion of the third reading of this measure Miss Wilkinson made reference to suggested amendments in reference to electrical installations and also the hirer's right to deal with the goods after one-third has been paid to the hire-purchase trader—in this case the municipal electrical authority—and the industry will await those amendments.

In the discussion there was a general acceptance of the principle of the Bill, but a number of practical difficulties were pointed out, which will presumably be brought forward when the Bill makes further progress, the general assumption being that it will become law.

The final paper on Thursday afternoon was on "Air Conditioning," the author being Captain J. C. Chaytor. The paper is largely based on information obtained from America, where air conditioning has made much greater progress than here, and the position at the moment follows very closely what happened with regard to refrigeration. The Americans developed refrigeration long before we did, and the position there led to it being pushed here with the success we all know. Now air conditioning is in the early stages of a similar push, backed by American experience. A start has already been made, for there are a number of air-conditioning plants in theatres, cinemas, large stores, and restaurants, but the extent of it is very small compared with the position in America, where, however, a start is only now being made on the domestic field. During 1937 something like 170,000 H.P. of new air-conditioning plant was added to the public supply mains in the United States, of which very little was residential load, and it is anticipated that in spite of the "business recession" in the United States, the increase in the connections during 1938 will amount to 240,000 H.P.

In England from inquiries made by the author it appears that the total horse-power in air-conditioning plant only amounts to about 70,000. It is pointed out that for a 2000-seat cinema an air-conditioning plant would cost £15,000, against only £4500 for a heating and Plenum ventilation plant, but it is contended that the growth of the air-conditioning industry in this country proves that the cost of obtaining the extra benefits of air conditioning is a wise investment.

An air-conditioning plant, known as the "Weathermaker," is described in the paper, and is regarded as an important contribution in enabling air conditioning to obtain a wider acceptance. It is factory made on a strictly scientific basis, and although a high degree of knowledge is necessary in planning an installation to suit the particular circumstances, its actual fixing is said to be simplicity itself, and its operation automatic. Both an air-cooled and a water-cooled model are made, the external dimensions of the cabinet in each case being 3ft. 4½in. high, 3ft. wide, and 1ft. 6in. deep. The water-cooled model has 10 per cent. more cooling capacity.

The author points out that whilst industrial air-conditioning installations have a good load factor, but little, if any diversity, on the other hand, comfort installations—*i.e.*, those not required for an industrial process—have a lower load factor and a higher diversity. In England the comfort installations are too few to enable any general figures to be given, but in the United States it has been found that in comfort

installations on commercial premises the load factor is about 15 per cent.

The most detailed returns are prepared, on a voluntary basis, in America, with regard to air-conditioning installations, and the author suggests that the electric supply authority in this country is the logical body to collect, collate, and disseminate such information as will facilitate a more widespread adoption of the idea of air conditioning.

In this case the discussion indicated that although some progress has been made with air conditioning for industrial purposes, and also for cinemas, theatres, &c., the position is not so good in other respects. People do not seem to take to a closed room with conditioned air, and cases were mentioned of hotels in which the occupants of bedrooms were asked by notices not to open the windows. Experience, so far, however, is that most people prefer "God's pure air," as they put it, to synthetic air, and therefore an educational campaign seems to be the next step in so far as air conditioning is to be applied for what is known as comfort conditions as distinct from industrial purposes. In other words, it is hoped to make the public "air-conditioned minded," to quote the advocates.

The annual dinner of the Association took place on Thursday, May 26th, and the principal guest of honour was Mr. Leslie Burgin, Minister of Transport. On this occasion the Minister departed from the usual custom of Cabinet Ministers at such functions—when great care is usually taken to say nothing which commits anybody—and stated in the most definite manner that the Government is determined to bring in a Bill to reorganise electricity distribution "at the earliest practicable date." He added that the Prime Minister had stated it was hoped to introduce the Bill early next session, and that that position still stood. At the same time he gave an assurance that suitable compensation would be paid to all officers and servants who might be displaced.

The President, in the course of his response to the toast of "The I.M.E.A.," which the Minister of Transport had proposed, expressed the hope that the period of indecision on the part of the Government would soon come to an end, because the delays that had occurred since the issue of the McGowan Report and the White Paper were having a harmful effect on the industry and were definitely checking progress. He emphasised that there was no division of opinion among the Council of the I.M.E.A. as to the manner in which the municipal electricity supply industry should be treated.

At the annual general meeting on Friday, May 27th, Mr. H. C. Lamb, Chief Electrical Engineer, Manchester, was elected President for the coming year, and Mr. J. Mould, Chief Electrical Engineer, Leicester, was elected Vice-President.

A Precombustion Ignition Coal Oil Engine

By J. R. KINGSTON, M.I.E.E., and W. R. POWELL, A.R.C.Sc., M.I.E.E.

ONE of the most pressing needs at the present time is a high-speed engine suitable for road transport that is capable of using creosote and other coal oils.*

It is well known that by the low-temperature carbonisation process, a ton of good bituminous coal will produce only about 3 gallons of motor spirit, whereas from 10 to 12 gallons of light oil can be obtained. This oil cannot be used in existing high-speed compression ignition engines, even if improved by the costly hydrogenation process. It is therefore converted to motor spirit by hydrogenation and used in petrol engines. Apart from the high cost of hydrogenation, it is common knowledge that for road transport service, including motor buses, the petrol engine uses approximately twice the amount of fuel, as compared with the compression-ignition engine.

The general introduction of an engine capable of using creosote directly with an efficiency comparable with the oil engine would therefore entirely alter the whole aspect of the problem of the home production of oil from coal and render the processing of the greater portion of coal used for domestic purposes by low-temperature combustion an economic proposition. In this connection, it is understood that creosote to British Standards Institution Specification No. 503 could be profitably sold at about 5d. per gallon. As this oil is free from any Government tax, the economy of its use is obvious.

The slow-speed oil engine can be readily adapted to use coal tar oils, but these oils cannot be used in high-speed compression-ignition engines, owing to the difficulty of obtaining rapid ignition on account of their high spontaneous ignition temperature of about 1000 deg. Fah., as compared with about 500 deg. Fah. for gas oil, and also their excessive delay period or ignition lag.

The attempt to overcome these disabilities by the use of very high compression pressures of above 40 atmospheres results in a very heavy and costly engine, which is not so flexible as when gas oil is used, and the acceleration is poor.†

To obviate the necessity for very high compression pressures, some success has been attained in Germany by the use of precombustion chambers which heat the air by means of a heat storage device situated at the point of maximum heat transfer.‡

This arrangement is fairly satisfactory so long as the engine is developing nearly full power, but the running at light loads is poor, and irregular, owing to the reduced temperature in the precombustion chamber. To solve this difficulty, the most simple method is to isolate the precombustion chamber from the power cylinder by means of a valve to maintain the minimum temperature required for satisfactory ignition, and adopt the efficient direct injection of fuel into the power cylinders for full loads.

As regards the separate combustion chamber, the authors commenced work on this problem over twenty years ago, and at that time there was a paucity of information regarding the behaviour of the combustion chamber lining and admission valve at high temperatures and pressures.

For this reason the small experimental model shown in the accompanying half-tone engraving, Fig. 2, was constructed by the authors about twelve years ago, and subjected to intermittent tests until recently. It must be distinctly understood that the object of the experiment was limited to proving the practicability of the special form of cooled valve and novel arrangement of refractory liner employed. No attempt was made to approach efficient compression beyond the use of cold jackets for the compressor cylinders, similar to present practice for small low-pressure compressors. In view of the above, the majority of tests were carried out with the inefficient compressor cylinders out of action, cool compressed air being obtained from high-pressure containers by means of the flexible pipe shown to the left of the engraving.

It is an interesting fact that, in spite of working at times with the proportion of fuel to air to give 100 B.Th.U. per cubic foot of free air, thus giving a flame temperature of over 3000 deg. Fah., no trouble has been experienced with either the admission valves or refractory lining.

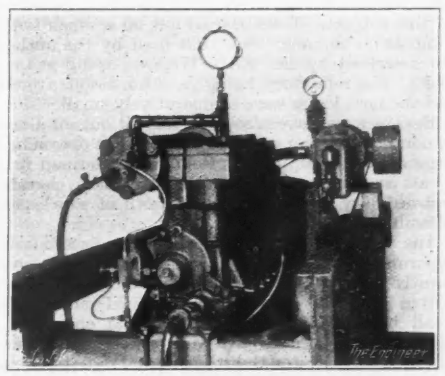


FIG. 2—EXPERIMENTAL ENGINE

The admission valves shown in the drawings reproduced herewith, Fig. 1, are of the thimble type, 1⅜in. diameter by 1¼in. deep; they are made of a good quality cast iron and work in a water-cooled guide cylinder. The combustion chamber is made from a 2ft. length of solid drawn steel tube A, 4in. internal diameter, with a mild steel block to form the admission port B welded on. The ends are mild steel circular plates, ⅜in. thick, provided with a copper-asbestos washer and clamped together with three ⅝in. diameter bolts. The tube is lined with a special silicous fire-clay sleeve C, ¾in. thick, a port being provided in the end. The lining is made with a clearance all round to enable a soft asbestos packing D to be inserted to prevent damage to the lining by vibration and also to reduce loss of heat by radiation. A ¼in. diameter screwed plug is fitted at the end of the chamber to enable the fuel spray to be ignited when starting up from cold by means of a torch. The fuel pump is driven at half engine speed by means of an excentric cam. The diameter of the plunger is $\frac{7}{16}$in. and the stroke adjustable from $\frac{1}{32}$in. to nil. It has two suction and one delivery ball valves, and is of very simple design, as its delivery pressure is only a few pounds per square inch above that of the combustion chamber. The spray nozzle is of the open type with a single hole.

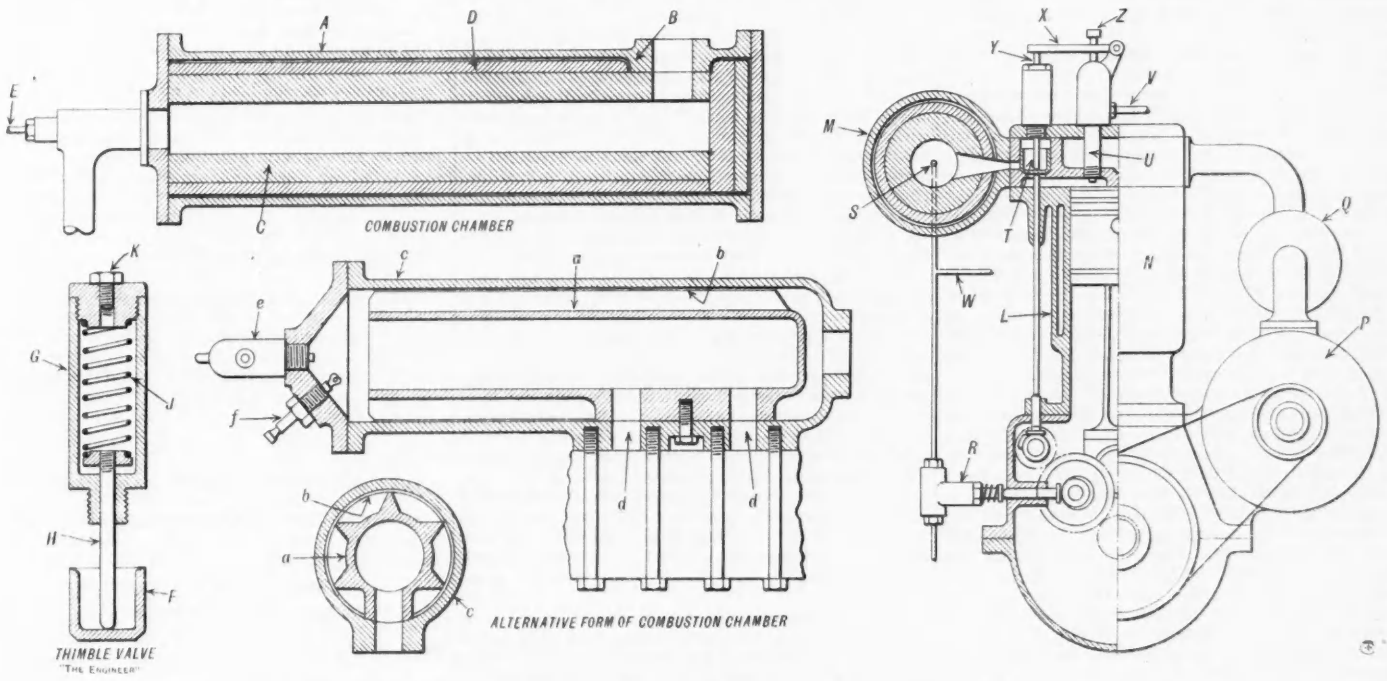


FIG. 1—DETAILS AND ARRANGEMENT OF COMBUSTION CHAMBERS, VALVES, AND ENGINE

* THE ENGINEER, April 30th, 1937, pages 508 and 511.

† M. Gautier, Rev. Comb. Liq., 1932.

‡ Karl Zimmer, Zeitschrift des V.D.I., August, 1936.

The model has four cylinders, 3¾in. diameter by 4in. stroke, two being used as power cylinders and two as single-stage compressors. The latter are fitted with heavy automatic valves of the mushroom type, which are unsatisfactory and gave much trouble.

Owing to the highly oxidising nature of the products of combustion and heated air passing from the combustion chamber, it was found essential to use a thimble inlet valve F, working in a water-cooled cylindrical guide and returned to its seat by an external spring mechanism comprising a casing G containing a rod H pressed by a spring J, as shown in Fig. 1. The screwed plug K is provided for the insertion of pure mineral oil with a little graphite.

The temperature of the valve was well below 1000 deg. Fah. and therefore entirely free from corrosion or erosion.§

During the last decade, and subsequent to the commencement of the above-mentioned experimental work, some valuable information has been published on this subject. Tests carried out on a much larger combustion chamber than that used by the authors are described by Dr. E. C. Wadlow, using gaseous fuel.‖ The refractory lining gave no serious trouble and the heat losses were comparatively small.

Experiments have also been carried out on a continuous combustion engine with a view to obtaining a large starting torque by a well-known German firm. A cast iron liner was used for the combustion chamber and ordinary mushroom valves, both of which gave difficulty owing to corrosion.

The forms of combustion chambers used in this experiment, and also by Dr. Wadlow, were comparatively short and of large diameter. It is submitted that the long refractory lined chamber of small bore used on our experimental engine is a distinct advance and gave very stable combustion. It will be appreciated that the internal radiation from the incandescent lining acts like a catalyst and greatly facilitates combustion. The lining could, however, be improved by using a quartz tube surrounded by sleeves of opaque material, such as fireclay and by insulating it from vibration by an asbestos blanket. Such a construction would entirely eliminate the possibility of detritus becoming detached and entering the power cylinder.

Although the continuous combustion cycle satisfactorily solves the difficulty of no load and light load working with a high-speed engine, using coal oils, owing to the fact that the maximum temperature permissible is limited to about 2000 deg. Fah. to preserve the refractory lining of the combustion chamber, the mean effective pressure is somewhat too low for road transport purposes.

It is therefore now proposed to fit auxiliary injectors on the power cylinders to spray oil fuel into the excess air contained in the products of combustion which pass from the external combustion chamber. It should, however, be distinctly understood that these auxiliary injectors have not been fitted to our experimental model, but a somewhat similar scheme has been tried with success in Germany.

This arrangement enables high maximum temperatures up to about 3500 deg. Fah., and therefore high mean effective pressures of about 7 atmospheres to be readily attained for full-power working, the engine thus working on a dual cycle, *i.e.*, partly continuous combustion and partly internal combustion. At light loads the auxiliary injection is out of action, the engine then working solely on the continuous combustion cycle. At full loads the temperature necessary for ignition of the auxiliary injection is attained by the simple method of combustion, *i.e.*, precombustion ignition, in lieu of the high compression necessary in the compression-ignition engine. The great advantage of this arrangement is that it combines the smooth running and comparatively low maximum pressure, say, from 15 to 30 atmospheres, of the continuous combustion cycle with the small bulk of the internal combustion engine, whilst using coal oils and the like.

A further advantage is that the maximum temperature in the external combustion chamber need not exceed, say, 1500 deg. to 2000 deg. Fah., which is similar to the exhaust temperature in petrol engines; it is ample with the assistance of the turbulence of the ingoing gases to ensure prompt ignition and complete combustion of the auxiliary spray with negligible delay or ignition lag. In this connection, from a chemical point of view, it is known that, to speed a reaction a hundredfold, it is only necessary to raise the temperature about 200 deg. Fah. above that required for ignition.

It is obvious that to attempt to attain sufficiently high temperatures by means of adiabatic compression to enable coal oils to be used is a much more expensive method than the use of a separate combustion chamber, particularly if the latter is used in conjunction with an exhaust recuperator.

With regard to the compression of the working fluid, it is quite possible to construct a workable engine in which the air is compressed in a single stage, either by separate reciprocating compressors or by using the power cylinders alternately as compressors. The disadvantage of this arrangement is that, as it is necessary to work at high speeds, say, 2000 r.p.m., the volumetric efficiency of such compressors is very low, *i.e.*, below 50 per cent., even if mechanically operated inlet valves are used.

A much more efficient arrangement is to perform the compression in two or more stages, preferably with intercoolers, the first stage being carried out in a rotary blower or supercharger. The rotary blower may also be utilised for operating the vehicle brakes in lieu of the rotary vacuum blower at present fitted to most high-speed oil engines for this purpose.

As regards the fuel injection, mechanically operated injection valves may be fitted to each power cylinder fed by the main fuel pumps on the so-called "common rail" system, or preferably separate timed fuel pumps and automatic injection valves of any standard make driven at camshaft speed should be used.

As coal oils and creosotes have a high viscosity of about 100 seconds at 100 deg. Fah. on the Redwood No. 1 viscometer, as compared with 40 seconds for gas oil used in high-speed oil engines, it is necessary to reduce the viscosity by fitting a heater on the exhaust manifold.

Owing to the fact that the engine starts and runs at light loads on the continuous-combustion cycle, the fuel pumps supplying the external combustion chamber are geared down much below the crankshaft speed. The high viscosity of the cold oil when starting is therefore of no importance. A 2-volt, 30-ampere K.L.G. glow plug is used to ignite the spray, similar to those used in high-speed oil engines.

The speed of the engine is controlled from the accelerator pedal at the lower powers when working on the continuous-combustion cycle by varying the fuel supply to the combustion chamber and the air supply. On further depressing the accelerator for full power, the delivery from the auxiliary fuel injectors is controlled by the well-known means used on compression-ignition engines. Neither maximum nor minimum speed governors are necessary, and the engine "ticks over" at no load with perfect smoothness and a total absence of "Diesel" knock.

The drawings show an end view of the engine having the suggestion applied thereto; the combustion chamber and power cylinder in half section; and the compressors in half elevation. Another view shows an alternative arrangement of combustion chamber with metal liner where lightness is essential. The engine comprises a power cylinder L, a separate external combustion chamber M, a reciprocating compressor N, a rotary blower (or supercharger) P, and an intercooler Q. One of the fuel pumps is shown at R, S is the fuel sprayer in the combustion chamber, T the inlet valve to the power cylinder, and U is the auxiliary fuel sprayer, which is supplied through the connection V from the pipe W.

In the arrangement shown diagrammatically, which operates on the so-called "common rail" system, the auxiliary fuel injector U is actuated by a lever X operated by an extension of the inlet valve spindle Y. There is a clearance between the spindle Z of the injector U and the lever X, the arrangement being such that the spindle Z is only raised when the lever is at the upper limit of its movement, *i.e.*, under full load. For light load the lift of the spindle Y is reduced, and in such case the lever X does not make contact with the spindle Z, and so the auxiliary injector is not operated. The fuel pumps must be arranged to give a steady delivery, thus requiring, say, three plungers set at 120 deg.

About one-third of the fuel supply is required for the combustion chamber fuel injector, and two-thirds for the auxiliary fuel injectors at full power.

Referring to the drawing which shows a proposed alternative arrangement of combustion chambers, *a* is a metal liner made of heat-resisting steel or an alloy such as nickel-chromium, surrounded by one or more layers *b* of metal foil, such as aluminium, with asbestos paper or other resilient non-conducting material between each layer to obviate radiation loss, and enclosed in a steel container *c*. The ports to the power cylinders are indicated at *d*. The fuel injector is indicated at *e* and the electrical glow plug for igniting the fuel when starting from cold at *f*.

With regard to the timing of the auxiliary fuel injection, this takes place at full load during the admission of the hot combustion products, the turbulence of which ensures complete combustion, somewhat similar to the blast air used in some Diesel engines.

From a purely theoretical point of view, it is advantageous to continue the auxiliary fuel injection, even after the inlet valves are closed, thus approximating to isothermal combustion. If an exhaust recuperator is used in lieu of a silencer, the temperature at which heat is added to the working fluid then approaches more nearly the maximum, this being the thermodynamic ideal. The practical objection, however, to a protracted injection is the increased loss of heat by radiation to the cylinder water jacket (*vide* hereunder).

We desire to place on record our grateful thanks to Dr. F. W. Lanchester, F.R.S., M. Inst. C.E., and to Dr. Ing. L. Frommer, for their valuable help and kindly criticism which have encouraged us to continue with this research.

THEORETICAL CONSIDERATIONS.

The fundamental difficulty in the continuous combustion engine is the large proportion of negative work, owing to the air having to be compressed and delivered against the maximum pressure. This negative work can be considerably reduced if the compression is carried out as nearly isothermally as possible, by the use of multi-stage compression. A cheap and compact arrangement can be obtained if the low-pressure compression is carried out in a high-speed rotary blower and the compression completed in two or more stages in reciprocating compressors, intercoolers being fitted between the stages. As with this arrangement the air is delivered comparatively cool, a considerable gain in thermal efficiency can be attained if the compressed air is passed through a recuperator through which the exhaust gases are passed in a contrary direction.

To enable some idea to be obtained of the thermal efficiencies that are possible with this cycle having isothermal compression and exhaust recuperation the following thermodynamic calculations and curves are given.

The air standard efficiency for different compression pressures and a maximum temperature of 2000 deg. Fah. is shown in Fig. 3, in which the

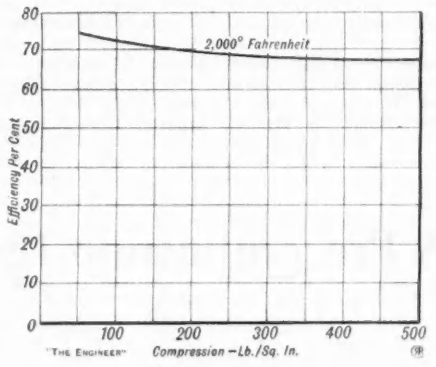


FIG. 3

ordinates represent thermal efficiency per cent. and the abscissæ represent compression pressure in pounds per square inch.

These efficiencies are calculated as follows:—

Let

P_1 = maximum pressure, absolute.
P_2 = atmospheric pressure, absolute, = 14·7 lb. per square inch.
T_1 = maximum temperature, absolute.
T_2 = atmospheric temperature, absolute, = say, 521 deg. Fah.
V_1 = volume of air at pressure P_1 and atmospheric temperature.
C_p = specific heat of air at constant pressure = 0·237.
J = Joule's equivalent = 778 foot-pounds.
D = density of air at pressure P_1 and atmospheric temperature.
γ = ratio of specific heats of air = 1·408.

Then assuming isothermal compression, heating at constant pressure, and adiabatic expansion carried down to atmospheric pressure, we have:—

$$R_1 = \text{ratio of compression} = \frac{P_1}{P_2} = \frac{V_2}{V_1}.$$

$$R_2 = \text{ratio of expansion} = \left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}}.$$

V_2 = volume at atmospheric pressure and atmospheric temperature $= \frac{V_1 P_1}{P_2}$.

V_3 = volume at pressure P_1 and temperature $T_1 = \frac{V_1 T_1}{T_2}$.

$$V_4 = \text{volume at end of expansion} = \frac{V_1 T_1}{T_2}\left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}}$$

Now, work done in compressing and delivering air at pressure $P_1 = P_1 V_1 (1 + \log_e R_1)$; deducting work done by atmosphere $P_2 V_2 = V_1 V_1$ we have

$$\text{Work done} = P_1 V_1 \log_e R_1 \quad . \quad . \quad . \quad (1)$$

Work yielded by volume V_3 including its expanding adiabatically $= P_1 V_3 + \frac{P_1 V_3 - P_2 V_4}{\gamma - 1}$.

Deducting work done against atmosphere we have

$$\text{Work yielded} = P_1 V_3 + \frac{P_1 V_3 - P_2 V_4}{\gamma - 1} - V_4 P_2 \quad . \quad (2)$$

$$\text{Available work} = (2) \text{ minus } (1) \quad . \quad . \quad . \quad (3)$$

Now, the heat supplied to the air

$$= J C_p V_1 D (T_1 - T_2) \text{ foot-pounds} \quad . \quad . \quad (4)$$

The air standard efficiency without regenerator is the ratio (3) to (4)

$$= \frac{\left\{P_1 V_3 + \frac{P_1 V_3 - P_2 V_4}{\gamma - 1} - V_4 P_2\right\} - P_1 V_1 \log_e R_1}{J C_p V_1 D (T_1 - T_2)} \quad . \quad (5)$$

This formula must be modified with the addition of a recuperator, as assuming that there is no loss of heat in the transfer from the hot exhaust to the cold working fluid, then T_2 becomes equivalent to the exhaust temperature, say, T_3. The work represented by the

§ "Factors Influencing Wear of Valve Seats," C. G. Williams, M.Sc., *Engineering*, March 26th, 1937.

‖ "Continuous Combustion at High Pressures," THE ENGINEER, December 23rd, 1927.

denominator in this formula—that is, $J C_p V_1 D (T_1 - T_3)$—is thus equivalent to the work done by the expansion in the numerator. The formula can therefore be simplified to :—

$$\frac{\left\{P_1 V_3 + \frac{P_1 V_3 - P_2 V_4}{\gamma - 1} - V_4 P_2\right\} - P_1 V_1 \log_e R_1}{P_1 V_3 + \frac{P_1 V_3 - P_2 V_4}{\gamma - 1} - V_4 P_2} \quad . \quad . \quad (6)$$

or

$$1 - \frac{P_1 V_1 \log_e R_1}{P_1 V_3 + \frac{P_1 V_3 - P_2 V_4}{\gamma - 1} - V_4 P_2} \quad . \quad . \quad . \quad (7)$$

The theoretical pressure-volume diagram for this cycle drawn to scale for a maximum gauge pressure of 200 lb. per square inch and a maximum temperature of 2000 deg. Fah. is shown in Fig. 4. The temperature-entropy diagram is shown in Fig. 5. This last-named diagram is plotted from the equation

$$\varphi_1 - \varphi_2 = C_p \log_e \frac{T_1}{T_2},$$

where C_p=specific heat at constant pressure. The ordinates represent absolute temperature in degrees Fahrenheit, and the abscissæ changes in entropy.

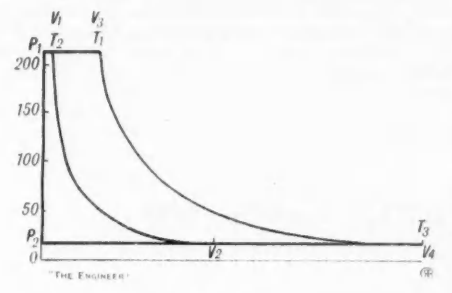


FIG. 4

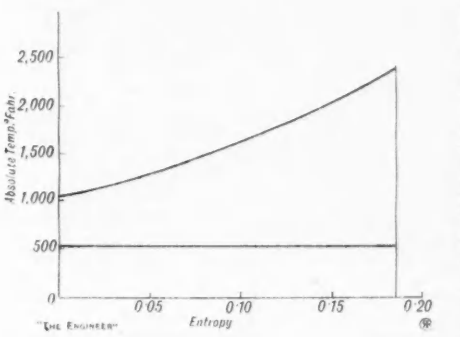


FIG. 5

It will be seen from these diagrams that the air standard efficiency is very high, being 70 per cent. with a maximum temperature of 2000 deg. Fah. and a maximum pressure of only 200 lb. per square inch, assuming that the compression is isothermal.

Theoretically, the air standard efficiency is not reduced owing to the increase of specific heat, as the increased heat in the exhaust consequent upon the increase in specific heat is absorbed in the recuperator. From a practical point of view, however, the increased specific heat increases the radiation loss through the cylinder walls, a portion of this heat being therefore non-recoverable.

To enable some idea of the heat loss through the cylinder walls to be obtained the theoretical air standard efficiencies for different temperatures with a compression pressure of 200 lb. per square inch have been shown in Fig. 6. The curve is calculated from formula (7) previously given.

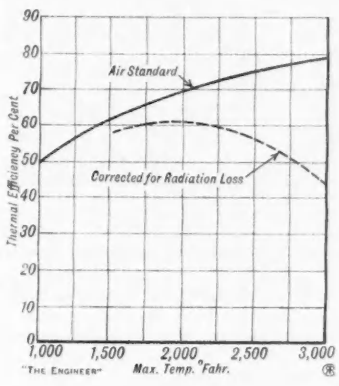


FIG. 6

To obtain the curve for the radiation loss it has been estimated that the water jacket loss at 3000 deg. Fah. would be about 35 per cent. of the total heat, which is approximately the case of the original oil engine, also having combustion at constant pressure and adiabatic expansion. The values for other temperatures are based upon the assumption that the loss varies approximately as the fourth power of the absolute temperature.¶

It will be seen from the curve Fig. 3 that the theoretical efficiency is influenced very little by increase in compression pressure. The compression pressure is, however, of great importance in determining the mean effective pressure and the temperature at the end of expansion to which the recuperator is subjected. With adiabatic expansion the temperature approximately follows the equation

$$\frac{T_1}{T_3} = \left(\frac{V_4}{V_3}\right)^{0.4},$$

where

T_1=maximum temperature, absolute.
T_3=exhaust temperature, absolute.
V_3=volume at maximum pressure and temperature T_1.
V_4=volume at end of expansion.

The loss due to radiation compensates for the increase in specific heat.

A very interesting point arises here regarding the comparative efficiencies of different thermodynamic cycles. As is well known, the air standard efficiency of 63 per cent. for the oil engine must be corrected for increase in specific heat of the gases at high temperature. Thus the corrected efficiency for a high-rated oil engine at full load is about 50 per cent. In the case of the continuous combustion and also the Carnot regenerative cycles, however, no correction is necessary owing to the increased heat in the exhaust being absorbed in the regenerator, but the water jacket and other radiation losses must be allowed for.

As regards the Carnot cycle, the continuous combustion engine could be easily arranged to work on this cycle if, in addition to the fuel pump for the combustion chamber, an ordinary oil engine pump and injector to each cylinder were added to maintain isothermal expansion.

There are, however, the three following objections to this modification :—

(1) At the same maximum temperature the loss through the cylinder walls is approximately four times as great as with adiabatic expansion, including the exhaust stroke.

(2) The recuperator has to withstand the maximum temperature instead of the much lower exhaust temperature, thus requiring expensive metals or alloys for its construction.

(3) The mean effective pressure with isothermal is much lower than with adiabatic expansion, thus necessitating much larger cylinders for the same output.

We thus arrive at the technical heresy that, although the Carnot cycle is the ideal for moderate temperatures (say, up to 1000 deg. Fah.), as used in steam turbines, it is not the ideal for high temperatures (say, above 2000 deg. Fah.), as used in internal combustion engines, when allowance is made for radiation losses at high temperatures.

¶ "Investigations of Gaseous Explosions," presented to the British Association at Dundee on September 5th, 1912, *et seq.*; also "The Rate of Heat Transmission from the Working Fluid in an Internal Combustion Engine," by Professor A. H. Gibson, D.Sc., *Philosophical Magazine*, Vol. XLVII, May, 1924.

Anglo-French Engineers' Fellowship.

THE visit to Paris of members of the British Section of the Société des Ingénieurs Civils de France on May 27th offered an occasion for showing what can be done to promote social relations between engineers of the two countries of a more intimate character than can be expected under the more formal conditions of international congresses. This idea of close social intercourse suggested the formation of the British Section in 1920 upon the initiative of the Marquis de Chasseloup-Laubat, the object being to exchange annual visits between Paris and London, and present papers, on the one hand, at the Société des Ingénieurs Civils, and, on the other, at British engineering institutions. Some of the most distinguished French engineers have given accounts of remarkable works for which they were responsible. It is not so much the technical side of the gatherings that give them importance as their social character, when engineers of both countries meet as members of the same society and are able to talk informally and freely of matters relating to engineering progress and interests. There may be special points of views on these matters on both sides, though the ends are always the same, and facilities for informal conversations help to a common understanding that leads to easier and more effective progress than would otherwise be possible. On the British side there is a belief that if all engineers were brought together by these means for a full comprehension of professional and social matters they would exercise an international stabilising influence. The French have certainly the same aspirations.

The membership of the British Section of the Société des Ingénieurs Civils is 160. The party visiting Paris comprised Mr. Halcrow (President), Sir George Humphreys (Past-President), Mr. Stanger (Vice-President), Mr. Howard (Honorary General Secretary), Mr. O. V. Bulleid (C.M.E. Southern Railway), Mr. Gilbin, Mr. Semet, Mr. Daniels and Mr. Gerard of the Royal Meteorological Society, and Mr. T. J. Gueritte. They were met on arrival in Paris by a delegation from the Société des Ingénieurs Civils, with the President, Monsieur A. Caquot, and were then entertained to dinner at the French Automobile Club. There was a large attendance at the Society's conference hall to hear communications read by British members. The meeting was presided over by Monsieur Caquot, and the British Ambassador showed his appreciation of the significance of the meeting by delegating his chief secretary, Mr. A. H. S. Yeames, to represent him. The three papers dealing with different phases of engineering and industrial activity in Great Britain covered no new ground, and were intended to interest French engineers, who knew little about them. Mr. Halcrow described hydraulic works in connection with the Lochaber power scheme, for which he was consulting engineer. Monsieur Caquot said that the undertaking was an excellent example of accurate calculations and of care taken for the safety of workers during difficult blasting operations. In his paper on long-distance express trains in Great Britain, Mr. O. V. Bulleid gave an account of the performances of fast British trains, notably the "Cheltenham Flyer," the "Bristolian," and the "Coronation Scot," and provided data of interest to French engineers. Lieut.-Colonel J. A. Ritson, Professor at the Royal School of Mines, was unable to accompany the party to Paris, and a paper by him on the British Coal-mining Industry was read by Monsieur Armanet, Professor at the Ecole Supérieure des Mines.

This meeting constituted the only business feature of the visit, and for the remainder of the time the members of the British Section were taken on a round of inspection of works in Paris, organised by the Metropolitan Railway Company and Monsieur Fauconnier, Director of New Metropolitan Constructions, which is a municipal department. During the visits they gave a banquet in honour of the British members at a restaurant in the Champs Elysées. The Société des Ingénieurs Civils and the municipal and Metropolitan Railway engineers left nothing undone to make the visit as pleasant and instructive as possible, and the British party returned to London on the following Sunday. It is expected that the Société des Ingénieurs Civils will shortly pay a visit to London.

THE PARIS SUBWAYS.

The British party, accompanied by a number of French engineers, was conducted over the northern section of the outer boulevards, which formerly constituted the military road inside the fortifications, which are now almost entirely levelled. On their site buildings with flats of modern design have been erected, the blocks being separated by open spaces, gardens, and playing grounds. This new boulevard, 21 miles round, has a roadway 54ft. wide which can be enlarged, if necessary, to 72ft. The main object of this boulevard was to relieve traffic in the centre of Paris by diverting as much of it as possible around the outer circle. As the circular traffic cuts the roads leading out of Paris, the only way of avoiding congestion at those points was to construct subways, except at certain places where there is sufficient room for an arrangement of giratory roads. The first subway was made at the Porte Dauphine, where the Avenue Foch, from the Arc de Triomphe, crosses the outer boulevard at the entrance to the Bois de Boulogne. Then followed seven other subways and another is under construction, while plans are ready for a continuance of this work as soon as funds are available for the purpose. The cost is heavy, owing to the preliminary work of displacing mains and flattening the roofs of underground railway tunnels, which are relieved of the load by arch construction over them to support the upper roadway. The usual method of executing the work is to excavate the subway in sections, remove the mains to each side of the road in concrete galleries, and then make the concrete subway, generally of parabolic section; but sometimes of rectangular section to meet special difficulties.

The Porte Dauphine subway was the first and easiest to construct on account of the absence of mains and the light traffic over it. It was completed in the middle of 1931 and has a length of 813ft., with approaches of 341ft. and 361ft., and an incline of 6 mm. per metre. The width is 44ft. and the height varies from 12ft. 6in. to 16ft. 6in. The Porte Maillot subway was opened a year ago. Its length is 1807ft., and its construction was complicated through passing

over two underground railway lines. The length necessitated attention to ventilation, which is effected by a natural displacement of air produced by bays on each side, but if it is found that a more thorough ventilation is needed it will be effected by pumping air through two galleries containing the mains and communicating with the inside of the tunnel by orifices covered by grids. So far, hardly any trace of monoxide has been found in the tunnels. The subway between the Portes Champerret and Courcelles was a more difficult undertaking on account of the necessity of diverting traffic through the tunnel by a bifurcating outlet and of passing over four lines of underground railway. The top of the Clichy sewage collector main had to be flattened, and other big mains displaced, and a rectangular section was given to the tunnel with central pedestals and arches to support the upper roadways, the arches spanning the underground railway lines and the big sewage main. In this subway the visitors were able to inspect the automatic arrangement for controlling the lighting, which is adjusted to the daylight intensity by photo-electric cells which vary the number of lights and their power, so that the lighting is always normal with respect to the daylight. Drivers of lorries are also warned if their load exceeds the height of the tunnel by means of photo-electric cells at the top of the downward approach which light up a prominent red caution on the portal of the subway. The driver must then turn off to the side road. The automatic control of lighting in the tunnel is remarkably complete. There are five circuits which follow one after the other if there should be successive failures, and in the event of an almost inconceivable collapse of all of them, an oil engine, which is always being ticked over by an electric motor, starts up and drives a dynamo. At the Porte Clignancourt the subway is under construction, and here again the top of an underground railway tunnel will have to be flattened. The shorter subway at the Porte de la Chapelle, having a length of 248ft., has straight concrete walls covered with two layers of reinforced concrete joists to support the roadway, and the mains are carried in galleries between the joists, while the electric mains for lighting are in a gallery in one of the walls at a convenient height. The subway is lighted by neon tubes, giving much the same luminous tone as daylight. At the Porte de La Villette the subway crosses over three lines of underground railway, necessitating an arch construction of walls, and its passing under the Est Railway offered difficulties through the necessity of not interfering with the running of trains above. The Porte d'Italie subway is of rectangular section offering no particular interest. There are hardly two subways quite alike, as they have to be modified and their arrangement completely changed according to circumstances. The external facings of the subways are adapted to the general tone and architectural types of adjacent buildings, a few with bricks and mostly with concrete of the desired form and colour.

Austerlitz Bridge Reinforcement.

The visit to the Austerlitz bridge which carries the Metropolitan Railway over the Seine, was particularly interesting, because it showed in progress a work that is being undertaken without any precedent. It is the welding of a reinforcement to a bridge that was built thirty years ago when the loads carried were less than a third of what they are at present. The bridge has a span of 459ft., and is composed of a parabolic arch with three articulated joints, two of which bear on consoles extending 55ft. 8in. from the abutments. Weighing 820 tons, it has always been noted for its appearance of lightness. The bridge was built for trains weighing 121 tons, and the trains are now more than twice as long and weigh 420 tons. By welding a reinforcement to the bridge the sections of the arch are increased by 60 per cent. and the weight is augmented to 1000 tons. It was assumed, and the assumption was confirmed by welding tests, that the original bridge would support the permanent loads and help to withstand overloads, while the reinforcement would only come into play under heavier stresses. In a word, the question was whether internal stresses due to welding would give rise to fractures in a structure where the welding would follow the lines of rivets, and a great many tests had to be carried out to show that internal stresses were localised in mild steel and disappeared altogether with the extra mild Martin steel, of which the bridge was constructed, reinforced with a rather milder steel and welded with special electrodes giving the same ductility to the whole. The reinforcements of the arches was made with bars 70 mm. by 140 mm., carefully prepared to fit between the rivets of the corresponding parts of the bridge. The under parts of the consoles were welded in position, and the rest was reinforced all over while 700 trains were crossing the bridge daily. It is declared to have been the most difficult welding operation yet undertaken. The entirely successful execution of the work is now assured, and this reinforcement by welding has preserved a bridge, which is admired for its elegance, and has avoided the necessity of a costly new structure.

Laboratories of the Travaux Publics.

The Laboratoires des Travaux Publics in the rue Brancion, Paris, are part of the equipment of the Ministry of National Education and Technical Instruction, and were created in collaboration with the National Federation of Building and Public Works Contractors. They were opened three years ago. The visit to this great building with two stories divided up for every kind of testing, and a basement installation for heavy testing operations, was instructive as showing the importance and value of the work being done to improve the quality of materials for building and structural work of all kinds, and to investigate the problems arising out of the newest research in the mechanical properties of soils for foundations. For the latter purpose, special machines have been designed by the chief engineer, Monsieur Langer. As the soil should be tested in its original condition a core extractor is used for the removal of samples. These samples are placed in bronze boxes with loose porous tops and bottoms, the inside surfaces of which are serrated. The top of each box is loaded, and the sample is allowed to remain until it reaches the limit of compression under that load. A load is then applied to the top along its horizontal longitudinal axis while the bottom is fixed, and the movement of the top under the load and the traction gives the measure of the shearing stress. Many other factors of soil characteristics are determined, and the laboratory was responsible for the preliminary foundation work of important buildings and bridges in Paris during the past three years. Concrete testing occupies a large place in the laboratory equipment, which includes a narrow bay with five 200-ton rams that were being used on a concrete structure, and also a 2000-ton press of special form for testing welded rings of high resistance steel bars. There is, in fact, a complete equipment for everything, down to machines for testing 15/10 mm. samples from welds, and a specially designed machine for giving alternating stresses to fine cable wire. There is also a complete equipment for testing soundproof walls and floors. This laboratory for testing all kinds of metals and materials is at the service of structural and other engineers, and a full account of it is given in a brochure which was presented to the British visitors.

Empire Exhibition, Glasgow.

No. VI.

(*Continued from page 616, June 3rd.*)

IN the following article we continue our description of the engineering exhibits at the Empire Exhibition, Bellahouston Park, Glasgow.

The Yorkshire Copper Works, Ltd.

On the stand of the Yorkshire Copper Works, Ltd., of Leeds and Barrhead, is shown a display of non-ferrous tubes, including condenser tubes and the firm's patented fittings for connecting light gauge copper tubing. Of special interest to Scottish visitors are samples of copper tubes from ¼in. to 8in. diameter and condenser tubes of several materials, including 70 : 30 cupro-nickel alloy, drawn in the recently erected works of the company at Barrhead. The firm has an old connection with Clydeside and Scotland generally with regard to the supply of tubes, and the new works have been erected with a view to an improved service for its Scottish customers. The works have a frontage on the main Barrhead and Paisley road, and they are adjacent to the L.M.S. goods and passenger station, with sidings leading directly to the London and Glasgow main line, so that quick delivery of tubes can be readily effected.

A large range of types and sizes of the firm's patented fittings, suitable for connecting light gauge copper tubes for copper pipe lines of every description is shown on the stand at the Exhibition. Reference to the accompanying engraving, Fig. 42, will

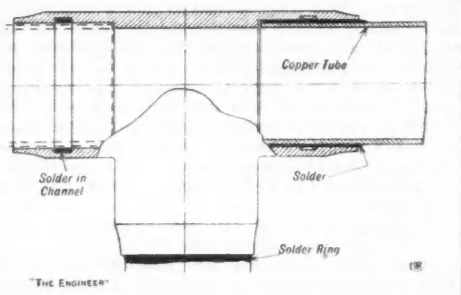


FIG. 42—COPPER PIPE FITTING—YORKSHIRE

explain the construction of the fitting and the principle on which the joint is made. Each arm of the fitting contains sufficient solder in an internal groove to make the joint. It is claimed that when the fitting and portion of the tube to be connected are heated, the solder is drawn by capillary action into all parts of the joint. To make the joint it is only necessary to clean and coat with flux the outside of the tube and the inside of the fitting, and apply heat with an ordinary plumber's blow-lamp. Heating is continued until a complete ring of solder appears round the mouth of the fitting, showing that the joint is completely filled. When the joint has been made, it forms a copper-zinc-tin compound which is stated to be stronger than the tube itself by reason of the alloying of the film of solder with the tube and fitting. It is also stated that the joint is immovable, except by the application of heat, but by the last-named means the joints can be taken apart and remade several times without, it is claimed, impairing the strength or the necessity for fresh solder.

In tensile tests performed upon "Yorkshire" fittings by the National Physical Laboratory two sample patterns tested fractured at stresses of 18·4 and 17·5 tons per square inch, and both fractures occurred in the copper tube. In that report it was stated that the strength of the soldered joint appeared to be equal to the tensile strength of the 19-gauge copper tube. Other tests, including paraffin seepage, alternate heating and cooling, and vibration tests, showed no effect on the joints, while a pressure bursting test showed that in every case the copper tube burst and no damage was done to the fitting or the joint.

Made in sizes from ⅛in. to 4in. in bore, from solid hot-pressed brass, the range of these fittings includes straight and flanged connectors and couplings, elbows, tees, bends, and so forth in both the standard and the disconnecting type. The last-named pattern consists of one or more arms of standard construction with a disconnecting arm having no solder but a union connector. This type is recommended for use in positions where the joint is to be broken repeatedly.

Robert Maclaren and Co., Ltd.

Many types of thermostatic control apparatus incorporating a new snap-action mechanism are on view on the stand of Robert Maclaren and Co., Ltd., Eglinton Works, 110, Kilbirnie-street, Glasgow, C.5. Disadvantages common in permanent magnets when used to produce a snap action in a switch, such as defects caused by demagnetisation from ageing, heating, hammer action, and neighbouring electric fields, are claimed to be eliminated in the compact mechanism exhibited, which is non-magnetic. Reference to the accompanying engraving, Fig. 43—a section through a typical thermostat, suitable for controlling room temperatures—shows that the device is also applicable to thermally or manually operated switches.

The device consists of a fixed contact A and a moving contact B, which is mounted on a resilient switch arm C forming part of a moving unit D. The

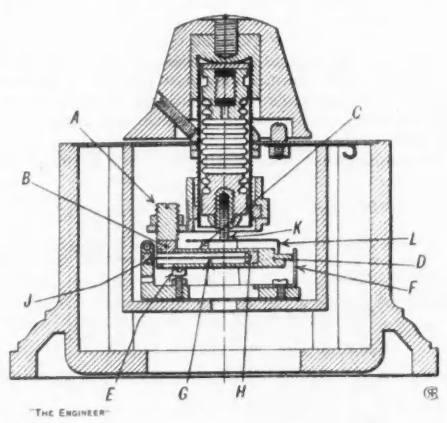


FIG. 43—SNAP-ACTION THERMOSTAT—MACLAREN

movement of the contact B is limited in the upwards direction by the stop A, which is adjustable. So that the amount of the gap can be regulated when the contacts are open, a stop E is arranged to limit the downward motion of the unit D. A spring cradle is arranged for the unit D by means of the spring bracket F, which exerts a pressure to the left, and the intermediary strut G, supported in frictionless bearings H and J. The unit D is supported on a knife edge at F, which is in a position slightly out of the line of the centres of the bearings H and J. The thermostat mechanism operates through an insulated point K pressing on the spring arm L, which is connected to the moving unit D of the mechanism. In this way an increase in pressure on the arm L, caused by an increase to a predetermined value of the room

temperature, exerts an increased force which causes the equilibrium of the triangle of forces—consisting of the force acting transversely through F and the reactions at the bearings H and J—to collapse, thus opening the contacts with a snap action. Relaxation of the pressure on the arm L results in the system returning to its former state, under the action of the forces tending to close the contacts. It will be noted that the arm L forms a lever which multiplies the force exerted by the thermostat. The arrangement illustrated is suitable for use with A.C. up to 20 amperes at 250 volts or for D.C. up to 0·1 ampere at the same potential. The dial is graduated in degrees, giving a range from 40 deg. to 80 deg. Fah., and the working control limits are stated to be within plus or minus ½ deg. Fah.

Applications of this device are shown in a number of thermostats for various kinds of temperature control. For most applications, such as tanks, circulators, &c., the temperature-sensitive element is composed of inner and outer tubular stems, the relative expansion of which operates the snap-action switch. In addition, there are shown on the stand several forms of thermostat consisting of an expanding bellows arranged to tilt by a mechanical action a mercury tube switch.

GLENFIELD AND KENNEDY, LTD.

In the Glenfield and Kennedy Pavilion, which has an area of about 1000 square feet and is situated close to the Palace of Engineering, there are arranged over

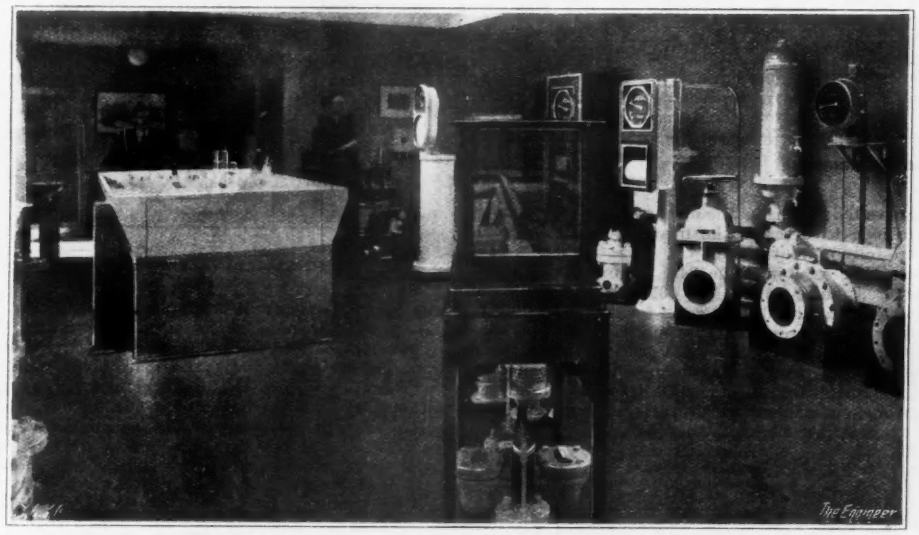


FIG. 44—EXHIBITS IN THE GLENFIELD AND KENNEDY PAVILION

one hundred exhibits representative of Glenfield and Kennedy, Ltd., of Kilmarnock, and its associated companies, the British Pitometer Company, Ltd., of London, and Hydrautomat (1931), Ltd., of London. In the accompanying engraving, Fig. 44, we illustrate the interior of the pavilion, in the foreground of which will be seen the scale models of the Vaal River Barrage and swimming pool with the Glenfield wave generating machine. Around the sides of the pavilion and in the central window are arranged various patterns of Glenfield valves and fittings, while, in addition, there is a series of flow recorders and meters and the latest design of Pitometer log, now fitted in many naval and mercantile ships. In what follows we propose to deal with some of the more interesting exhibits.

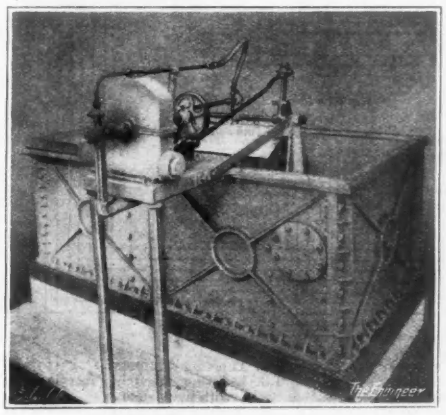


FIG. 45—ROTARY STRAINER—GLENFIELD

In Figs. 45 and 46 we show one of the latest designs of Peebles rotary strainer with a drum of 2ft. 6in. diameter and a width of 2ft., which is driven by a water motor operated from a supply of low-pressure water, from which the cleaning jets are also supplied.

The revolving drum is covered on the periphery with wire cloth of fine mesh, or perforated plate, according to the duty for which the strainer is intended. One end of the drum is closed by an end plate which carries the central shaft on which the drum turns, supported on external bearings. The other end of the drum is closed by an end plate having a concentric inlet opening which fits closely against an intake casting bolted to the cast iron tank containing the strainer. The circumferential joint between the end plate and the inlet casting has a very fine clearance and is furnished with gun-metal facing rings and a flexible seal which prevents leakage without creating more than a negligible frictional resistance.

The drum is rotated at a circumferential speed of about 3ft. per minute by a double-acting ratchet mechanism driven by the motor through worm and bevel reduction gearing. The motor also actuates the oscillating water jets which are arranged to clean the whole surface of the screening medium as the drum rotates.

Entering the drum axially, the water to be screened flows radially through the screening medium to the outlet pipe. *Débris* held back by the screen is retained inside the drum and is carried up by longitudinal lifting bars fixed to the inside of the drum and arranged to discharge into a waste trough fixed with its lip above the water level. This trough is connected to a waste pipe, which in an actual installation carries the discharge to a convenient point for disposal. The action of the cleaning jets frees the straining surface from intercepted impurities retained on it and flushes all the *débris* into the trough. The oscillating jets are a patented feature of the machine and are claimed to result in economy of wash water. The exhaust from the water motor driving the machine can, in an actual installation, be used to assist in flushing the *débris* to waste, or if it is desirable to avoid wasting the water it can be exhausted to the intake chamber and passed through the screen back to the supply. The speed of the drum is adjustable from the minimum speed of about 3ft. per minute at the circumference to about 9ft. per minute.

Where water is not available the screen can be driven by a small electric motor of about ½ B.H.P., which can also be used to drive a small pump to supply the cleaning jets and, if desired, a *débris* pump to lift the screenings to any convenient height should gravity disposal not be practicable.

Strainers are available with capacities ranging from 30,000 to 1,000,000 gallons per hour, having drum diameters from 2ft. 6in. to 7ft., but much larger units are regularly designed and Peebles strainers having drums 14ft. diameter by 10ft. long are at present being constructed.

The principal applications of the Peebles rotary water strainer are in waterworks, reservoir draw-offs, and at river intakes, and also as a pre-filter for the purpose of reducing the load on slow sand filters or mechanical filters when the water contains a troublesome percentage of larger suspended impurities. The machine is also suitable for sewage screening, steam power station cooling water, and other industrial purposes.

Another interesting machine exhibited is the four-ton Peebles sand washer shown in the accompanying drawing, Fig. 47, from which it will be seen that the sand to be washed is fed into the first hopper from which it is ejected, by means of a water jet, up an inclined tube on to an oscillating screen which separates the stones and large lumps from the sand itself. The sand falls through the screen into the second hopper of the machine, and, in passing through the water, is agitated by a stream entering from the next hopper above. The bulk of the dirt is thereby washed from the sand and floats to the water surface, overflowing to waste. In falling further, the sand encounters another jet which performs a similar function, and is finally ejected up an inclined tube into the third hopper, where it is agitated by the water entering from the next hopper above, which takes with it *débris* to the one below. Another ejector lifts the sand to the fourth hopper where a similar action takes place, and it passes thence to the final hopper, from which the clean sand is ejected on to a heap or into trucks.

Economy of water is secured by passing it successively through each of the hoppers in turn, the cleanest water being in the final hopper where the sand is also cleanest. The machine thus operates on the contra-flow principle, the water meeting the sand in its progress through the machine, and an effective scrubbing action is secured by an arrangement of auxiliary jets at the entrance to each of the ejector tubes, shown in the drawing, which causes the sand particles repeatedly to change their directions of motion. The screen is oscillated by means of a water motor, and thus the whole machine is hydraulically operated and needs no other external power. Complete control of the wash water is provided by the regulating cocks and baffles which enable the machine to be set to wash sand containing any percentage of impurities.

These sand washers are suitable for operation by unskilled labour, as, once the water has been turned on, their operation is automatic, and it is only necessary to feed the dirty sand into the first hopper and cart away the washed material after it is ejected from the last nozzle.

They are supplied in three sizes with designed capacities of 4, 8, and 12 tons per hour, both as portable and fixed machines.

In the engraving, Fig. 48, we illustrate the "Hydrostat" positive meter chemical pump for the proportioning and injection of chemical reagents in water-treatment plant, which is shown in operation on the stand. The maximum capacity of the unit is 10,000 gallons per hour of water passing through the driving end, and the machine is designed to work accurately with flows ranging down to about 700 gallons per hour or less, giving a range of flow treatment of about 15 to 1, sufficient to cover most requirements in water softening and filtration plant. The head loss across the driving end of the machine at the upper limit of the flow range is about 15ft. and at the lowest flows for which the machine is suitable the head loss is less than 2ft.

Other sizes can be supplied with capacities ranging from 1500 to 40,000 gallons per hour. The pumps are suitable for handling any of the reagents commonly employed in water treatment engineering, such as lime suspension, sodium carbonate, alumina sulphate, ferric sulphate, potassium permanganate, chlorine and ammonia solutions, caustic soda, and tri-sodium phosphate.

The driving end of the pump consists of a cylinder

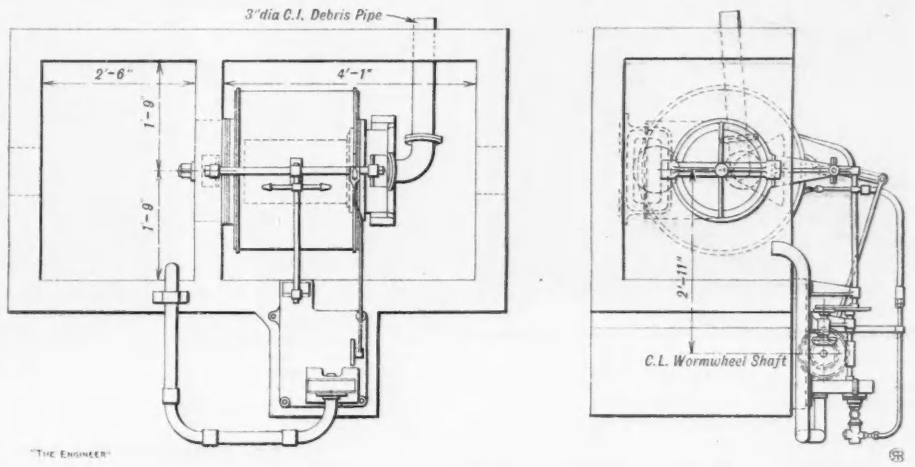


FIG. 46—ARRANGEMENT OF ROTARY STRAINER—GLENFIELD

with a piston, with an operating valve and a pilot valve, mounted on a base, to which are attached one, two, or three chemical pumps driven through links from radius arms by the piston-rod.

The flow of water to be treated passes through the driving cylinder and is directed to alternate sides of the piston by means of the operating valve which is moved hydraulically under the control of the pilot valve. Reciprocating motion is thus obtained and transmitted to the chemical pumps. It will be obvious that the driving end is, in effect, essentially a positive type water meter, and that the displacement of the piston is therefore directly proportional to the volume of water passing through the machine. With the driving links of the chemical pumps fixed at given points on the radius arms, the displacement of the chemical pumps is also directly proportional to the water flow, and remains strictly so however the water flow fluctuates. It follows that if the stroke of the motive piston is constant, that the rate of stroking of the machine is directly proportional to the rate of water flow. If, however, the length of the stroke should vary slightly at different flows, the length of chemical pump strokes will vary similarly, and strict accuracy of chemical delivery is, it is claimed, always assured. Adjustment of the chemical dose is obtained by alteration of the radius at which the links are fixed to the arms.

We have already referred above to the model of the Glenfield wave generating plant, the interesting feature of which is the ability to vary the appearance of the waves. With this plant no two waves following one another down the pool are exactly alike; the wave crest is generally highest on one side and lowest on the other, and gradually changes until the wave is uniformly high across the width of the pool, then gradually it changes until the form is the opposite of that first observed. The wave form then slowly changes back again throughout a complete cycle. A series of waves, each of which differs in character from every other wave, can be produced following each other in regular succession, and this series can be repeated as long as the machinery is kept running. We hope to describe the mechanism of this plant more fully in a later issue.

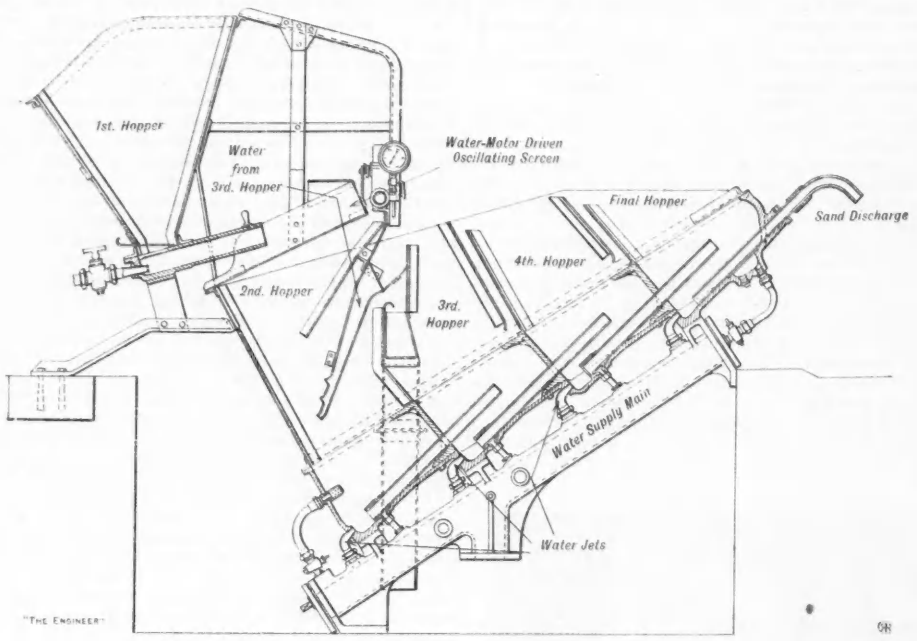


FIG. 47—SAND WASHER—GLENFIELD

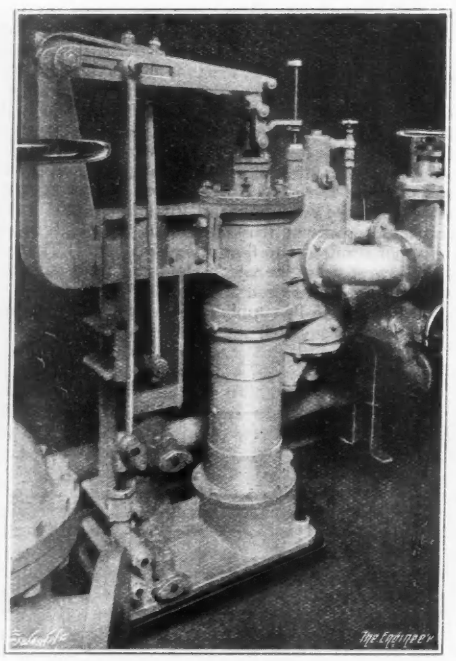


FIG. 48—HYDROSTAT CHEMICAL PUMP—GLENFIELD

Another exhibit is the 24in. diameter electrically operated sluice valve, Fig. 50, controlled by local, intermediate and distant push buttons, and with an intermediate lamp indicator unit and distant valve position indicator. The valve belongs to a series designated Series 1, and is designed for a test pressure of 200 lb. per square inch. It is operated through machine-cut spur and worm gearing, and the mild steel worm is forged solid with the shaft. The worm wheel is composed of phosphor bronze, and all the gearing is enclosed in a casing forming an oil bath. Ball thrust washers are fitted at each end of the worm shaft. A pointer moving over a graduated brass scale shows the relative opening of the valve. A roller attached to this pointer engages with the arms of the limit switches mounted on the indicator hood.

The motor is a 380/400-volt, three-phase, totally enclosed, reversible machine, intermittently rated, and capable of developing a high starting torque when switched directly on the line. It has a skirt flange for mounting on the worm gear case and the shaft rotates in totally enclosed grease-filled ball bearings.

The limit switches which stop the valve at the end of the travel are self-resetting, single-pole, shunt-coil units. One opens the circuit breaker in the "Valve Open" position and the other at the closed position, and ensure that current is supplied to the motor for the correct direction of rotation. For use in the event of the current failing, there is a hand-operated crank, which engages with a square on the end of the worm shaft, but the crank cannot be engaged without opening the cover of a Glenfield interlock switch, thus breaking the motor control circuit, and making it impossible for the motor to run under power while the hand crank is in use.

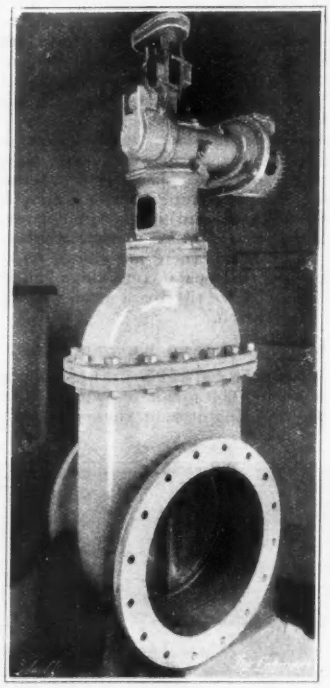
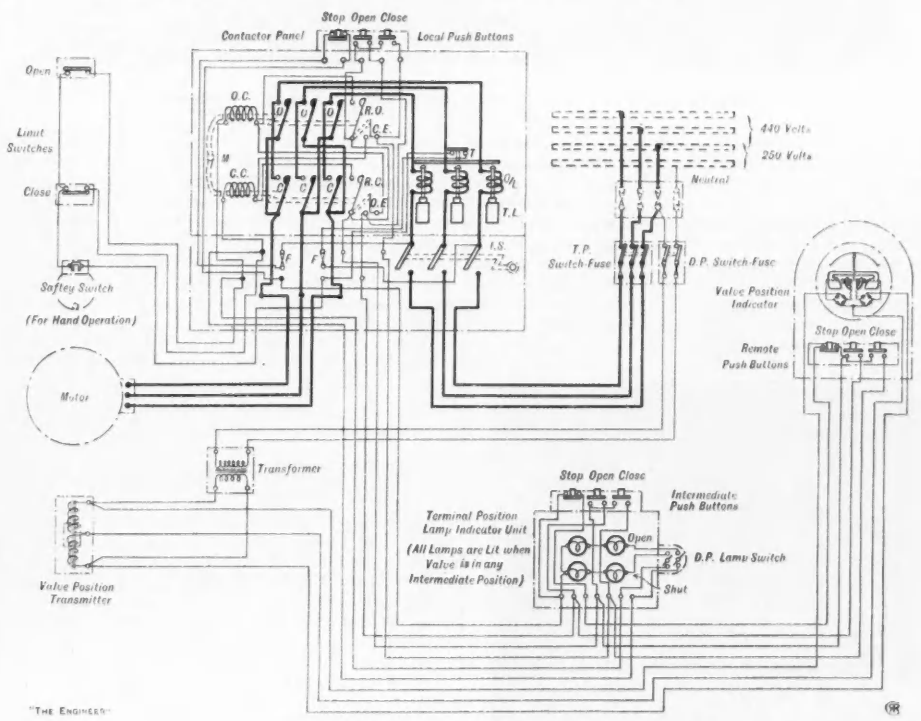


FIG. 50—SLUICE VALVE—GLENFIELD

The local, intermediate and distant push-button units each comprise three buttons, marked "Stop," "Open," and "Close" respectively. Normally the "Stop" switch is closed, and when the button is pressed it opens the control circuit and causes the stator contactors on the starting panel to open. The "Open" and "Close" switches are normally open, and when the buttons are pressed the control circuit



O.C. "Open" contactor coil.
C.C. "Close" contactor coil.
O. "Open" contactors.
C. "Close" contactors.
R.O. Retaining contactor for "open" contactor coil.
R.C. Retaining contactor for "close" contactor coil.
C.E. "Close" electrical interlock.
O.E. "Open" electrical interlock.
T. Self reset overload trip bar.
O/L. Magnetic overload coils.
T.L. Time lag dashpots.
I.S. Isolating Switch, interlocked with panel door.
M. Mechanical interlock.
H.S. Hinged sheet metal shroud.
F. Auxiliary circuit fuses.

FIG. 49—DIAGRAM OF CONNECTIONS FOR SLUICE VALVE—GLENFIELD

is completed to energise the "Open" contactor coil and the "Close" contactor coil respectively. A

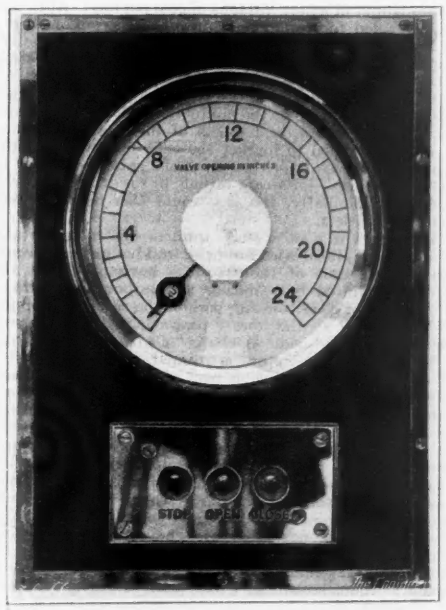


FIG. 51—VALVE INDICATOR—GLENFIELD

diagram of connections is given in Fig. 49. When the stator contactor closes it also closes a retaining contactor in the control circuit, which is wired in parallel with the appropriate push buttons. Thus when the "Open" or "Close" push button is released the circuit it completed is maintained through the retaining contactor. When the valve is opening or closing it is necessary to push the "Stop" button before the valve motion can be reversed.

On the lamp indicator unit, which incorporates the intermediate push-button unit, there are red and green lamps, and two lamps hidden from view serve as resistances to enable the line voltage to be applied to standard lamps. When the valve is fully open the green lamp burns and when closed the red lamp. In intermediate valve positions between fully open and fully closed, both the green and red lamps burn. A hand switch enables the lamps to be extinguished when required.

The Evershed valve position transmitter consists of a totally enclosed choking coil mounted in a solid-drawn steel tube over which a copper sleeve travels. It is mounted on the valve hood and the movable copper sleeve is connected to the valve spindle. As the unit is totally enclosed, it is suitable for the most exposed positions, and as the action is based on induction, no moving contacts are employed.

With its scale graduated to show the valve opening in inches, the valve position indicator, shown in Fig. 51, consists of a special D.C. voltmeter, with metal rectifiers for converting the A.C. to D.C. Within reasonable limits voltage and frequency variations do not affect the accuracy. The indications are continuous and even after a failure of current the indicator gives a correct reading after the supply is restored. The indicator is exhibited as an alternative to the lamp type which only shows whether the valve is fully open or closed, and is employed when the position of the valve door is required at any point of its travel. Other remote indicators are available to suit the individual requirements of engineers.

(To be continued.)

A Steam-Generating Turbo-Motor.

THE steam generating t rbo-motor illustrated herewith has been built by a French engineer who is at present completing tests on a unit to be used in an Army lorry. The inventor of the motor, Monsieur Bechard, defines it as "a thermic machine of the first degree which transforms heat into mechanical energy by means of steam, produced and utilised in a single apparatus."

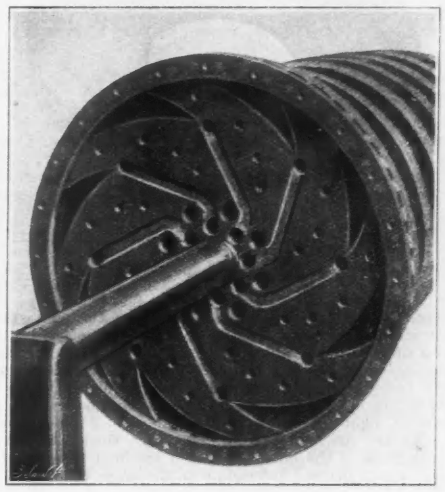
The motor consists of a series of hollow discs mounted on a shaft. The interior of each disc is divided into two parts by a circular baffle plate. Succeeding discs are connected to each other by a short length of tube which acts as a spacer and leaves an annulus around the shaft, which permits the circulation of fluid from one disc to the next. A water inlet hole is drilled in one end of the shaft as far as the first disc, to which it is connected by four tubes. This part of the machine constitutes the boiler.

On the same shaft and placed after the last of the motor rests. Water is fed from a tank to the boiler by gravity. Because of the position of the nozzles at the end of the motor it is not possible for the boiler discs to fill completely with water, for when the water reaches the outlet of the last disc it runs out by the nozzles. The quantity of water in the boiler is, therefore, very small, and is only about 10½ pints in the motor now completed. The gas burner under the boiler is of an ordinary industrial type. It is arranged so that the flame heats the last of the boiler discs first. The flame passes round inside the casing and around the motor in a spiral, and the products leave the casing by a flue at the front of the first boiler disc.

Each nozzle is controlled by a valve which permits the steam produced in the boiler discs to be turned on when a sufficient quantity has been produced to start the motor. The centrifugal force causes the water at first to spread in a ring around the periphery of the discs side of the baffle it is displaced towards the centre by the heavier and cooler water behind it. When the motor is running at full speed it actually sets up a suction which draws water up from a reservoir. This reservoir is placed so that when the motor is at rest the level of the water in the boiler is the same as that in the reservoir.

As the discs turn in the flame their friction against the burning gases accentuates the spiral shape of the flame with the result that the whole of the outer surface of the boiler appears to be enveloped in a swirling mass of burning gases.

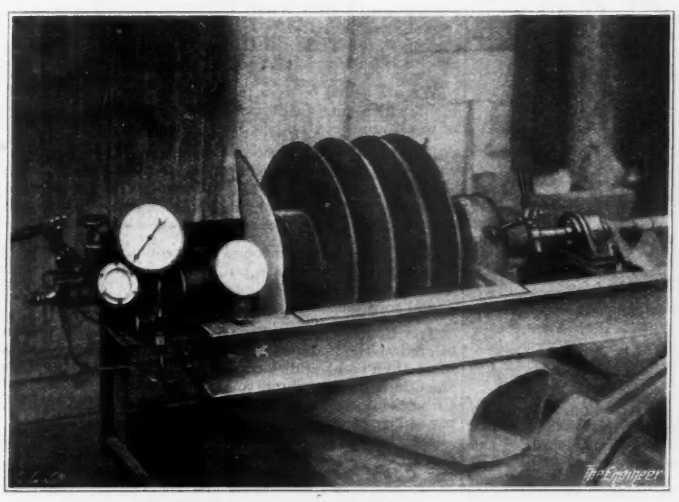
The motor, it is claimed, cannot develop an internal steam pressure greater than that for which it is built, and automatically adjusts itself to the external load by increasing or decreasing its steam production. Thus, if the load increases the motor will be temporarily slowed down, and the decrease in the centrifugal force will permit the water to advance along the line of discs so that it will be present in the boiler in greater quantity, thus



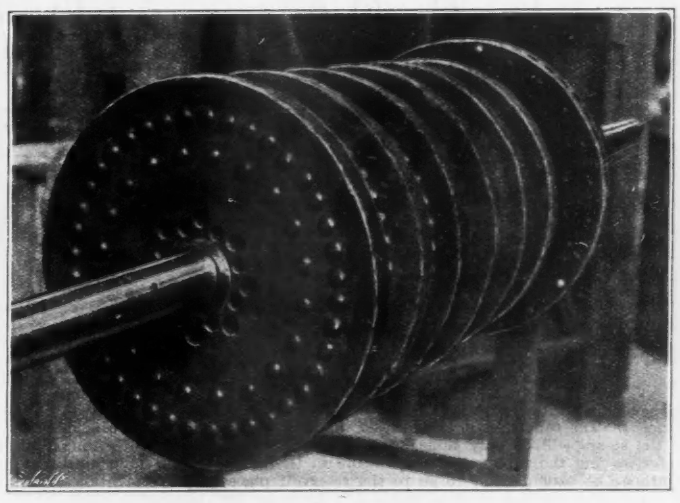
MOTOR FROM OUTLET END

producing more steam. As the quantity of steam produced increases to the point required to balance the new load, the increasing steam pressure in the boiler will force the water back again, reducing the amount present until a balance is reached between the load and the amount of steam produced. In the same way, if the load on the motor is reduced, the steam pressure accumulating in the end discs of the boiler forces the water back in the first discs, reducing the amount of water in the boiler, and hence the production of steam.

One of the effects of the centrifugal forces in action is, it is claimed, that no scale is formed in the discs and no deposits from the source of heat are caused on the outside. This fact is stated to have been proved experimentally in the test motor which Monsieur Bechard has had in operation for some time. After running for eighty-five hours, the motor was dismantled and the inside of the discs examined. No trace of any scale formation was found. This result is explained by the fact that as rapidly as particles of scale are formed, the centrifugal force in the boiler acts to carry them along in the stream of fluid



35 H.P. STEAM-GENERATING TURBO-MOTOR



BOILER DISCS FROM INLET END

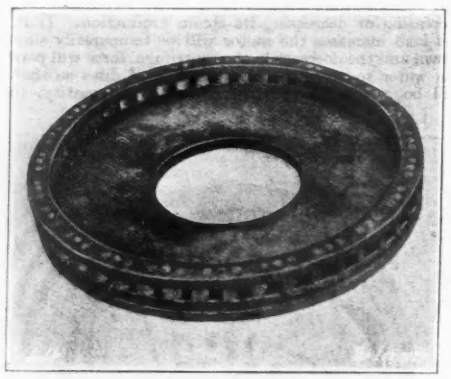
above-described "boiler discs," is a further disc inside which a series of channels ending in nozzles at the edge of the disc is machined. These channels connect with the hollow of the last boiler disc, so that the fluid in the boiler may escape by the nozzles. A ring consisting of a series of fixed turbine blades held between two plates fixed to the frame of the motor is arranged round the outside of the nozzle disc. The fluid escaping from the nozzles strikes the blades, the reaction causing the shaft carrying the boiler discs and nozzles to revolve.

Under the boiler discs a source of heat is provided. In the motor now built this source of heat is a gas burner using producer gas, but in the experimental machine which Monsieur Bechard has been using it is a fuel oil burner. Any other source of heat might be used. The whole of the motor is enclosed in a heat-insulating casing, at each end of which is a bearing in which the shaft of the leaving the centre of the discs free for the collection of steam. As steam forms in the last boiler disc, it forces the water in that disc back, causing it to flow into the preceding discs so that the boiler discs at the outlet end tend to become filled with steam only. When the motor reaches full operating speed the steam pressure will have acted to fill the first discs with water, and the last discs with steam. The boiler is thus divided into three zones, the first serving for heating the water, the second for its evaporation into steam, and the last for superheating the steam which then escapes by the nozzles. At full speed centrifugal force helps the circulation of both the water and flames round the boiler. The escape of the steam causes a natural flow of the fluid in the boiler towards the nozzles. This flow is aided by centrifugal force at one side of the baffle plate in each disc. As the water heats up it becomes lighter, and therefore on the other through the boiler so that the scale is ejected with the steam from the nozzle. The action of centrifugal force also explains the failure of the source of heat to cause a deposit on the outside of the discs. Any particles which may tend to adhere are immediately subjected to the centrifugal force set up by the rotation of the boiler, which loosens them from their support and throws them outwards away from the surface of the boiler.

The motor on which tests have been made consists of a series of boiler discs in ordinary boiler plate. Each boiler disc is formed of two outer plates 0·19in. thick, welded to a ring which connects the peripheries of the two plates, thus forming a cylindrical box 12in. in diameter and about 1½in. wide. A baffle plate divides the interior into two, so that a space for fluid about ⅝in. wide is formed. Six of these discs are shrunk on to a steel shaft 1·37in. in diameter. They are spaced about 3in. apart by a

length of steel pipe. The water is admitted into the boiler by a hole about ⅜in. in diameter in the end of the shaft. This hole connects with the inside of the first boiler disc by means of four short pieces of tube which run from holes in the face of the first disc to holes drilled radially in the shaft and connecting with that drilled in the end of the shaft.

The last of the boiler discs is connected with the outlet or nozzle disc by an annular space exactly like those between the boiler discs themselves. The outlet disc consists of ⅛in. boiler plate in which a series of channels is milled. To each side of this plate a plain disc of boiler plate is



FIXED BLADE DISC

riveted so that the channels form tubes through which the steam can flow. The end of the channels is milled to a suitable nozzle shape. The whole of this part of the motor—shaft, boiler discs, and outlet disc—rests in two ball bearings fixed on an angle iron frame which forms the frame of the motor and also carries the heat-insulating case of light sheet metal and asbestos. The turbine blades are cut from steel of the same thickness as the inner plate of the outlet disc, and are held between two sheet metal plates fixed rigidly to the angle iron frame of the motor. The space between these two sheets and beyond the ends of the fixed blades forms a chamber in which the exhaust steam collects and from which it is led to a condenser. The condenser is similar in construction to an ordinary motor car radiator. The steam passes through the condenser tubes while air passes over their external surfaces. The condenser is designed so that the cooling of the steam will be only sufficient to condense it, the water leaving the tubes at a temperature in the neighbourhood of boiling point to go to the reservoir placed at one side of the motor, from which it is drawn by the suction of the motor as it is needed. The air, after passing over the condenser, is used as secondary air for the gas burner, which is placed under the revolving boiler. In this way a considerable amount of the heat produced by the burner is recuperated.

The controls of the motor are three. One is on the feed water pipe between the reservoir and the boiler, the second is on the gas flow between the gas producer and the burner, and the third is on the valves controlling the steam discharge from the nozzles. The last of these controls governs the amount of power used and the first two the amount of power produced by the motor. In operating the feed water and the gas flow controls, it is important that a proper relation between the two flows should be maintained. If too great a flow of water is permitted the heat from the burner will not be sufficient to evaporate it properly. This is of secondary importance since the flow of water is automatically controlled by the speed of rotation of the boiler. In fact, however, the speed of rotation is normally constant, no matter what the power. If the amount of gas fed to the burner is reduced, without also reducing the flow of water, the speed of the boiler will fall and the steam produced will be insufficiently heated. Only if the amount of feed water is reduced at the same time can the speed of the boiler be maintained at its proper value with a smaller production of power.

The control of the steam outlet takes the form of slides in the channels in the outlet disc. Each of these slides is governed by a short rod connected to a ring which revolves with the motor. This ring is placed between two sets of fingers which can be moved longitudinally by means of a control lever. In order to give the motor flexibility of output the sixteen slides in the steam outlet

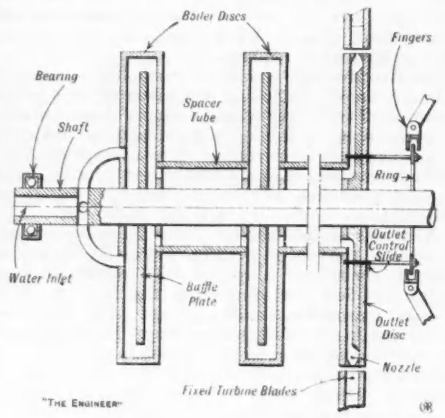
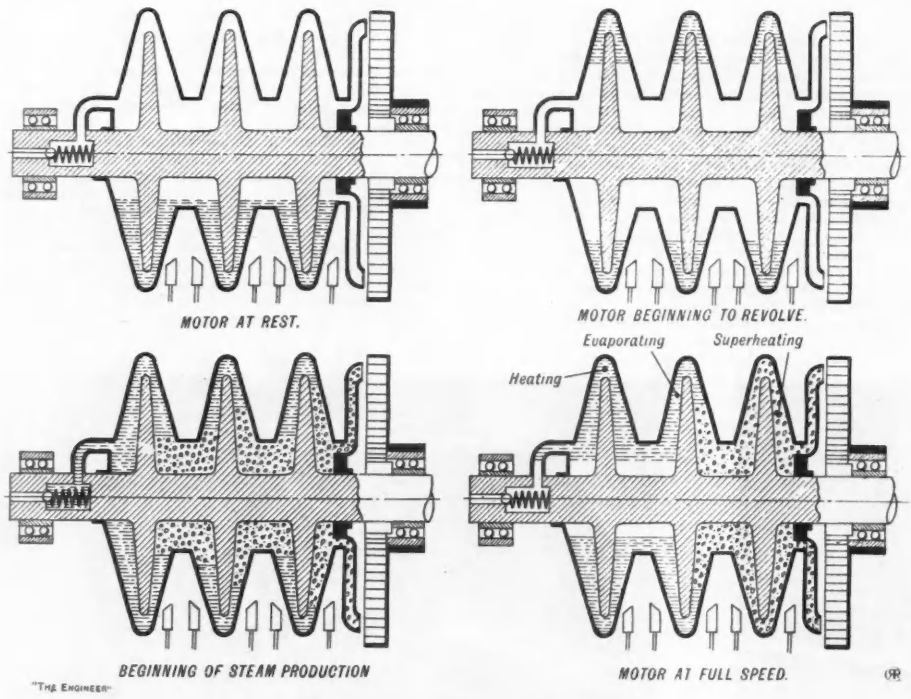


DIAGRAM OF TURBO-MOTOR

channels are arranged in four series of four, each series being connected to a separate ring controlled by a separate lever. The capacity of the motor can therefore be varied in four steps.

The motor built for the French army operates on unpurified producer gas, but it might equally well, it is claimed, be operated on fuel oil merely by changing the burner and replacing the gas producer by an oil tank. This possibility of using any available fuel, it is contended, can be of considerable advantage, especially for military lorries. Another point urged in favour of the motor is its simplicity of construction. Ordinary boiler plate is used and the whole motor makes use of only two bearings, one at either end of the shaft. The motor now built has, under test, produced 50 B.H.P. when operating at a speed of 1800 r.p.m. The steam pressure is 425 lb.



ACTION OF BOILER DURING STARTING

Test of a Rotary Retort.

A REPORT published by the Department of Scientific and Industrial Research gives the results of a test by the Director of Fuel Research on the Morgan rotary retort installed at Rodridge Hall, near Wingate, Co. Durham. The test was carried out under powers conferred by the Government, whereby the Department may test low-temperature carbonisation plant at the public expense, subject to certain conditions. The object of these tests is to place in the hands of those interested accurate technical data on the quality and quantity of the yields, the throughput of the plant, the working temperatures, &c., and the general ease of working. No attempt is made to pronounce on the commercial possibilities of the plant, for these can only be judged after working at steady load for long periods and in the light of complete knowledge of local conditions of prices, markets, and costs.

The plant is of intermediate-scale size, and deals with a throughput of about 4–6 tons of coal per day. Although not intended for commercial operation, it is considered to be large enough to yield data capable of being interpreted directly in terms of a commercial scale unit treating about 30 tons per day.

The object of the process is stated by the inventor (Mr. J. S. Morgan) to be the production of low-temperature coke, primary tars, and a gas of high calorific value. It is not intended to market the coke for domestic purposes, but to use it—either on chain grate stokers or in pulverised form—for steam raising, or for other industrial purposes. Similarly, the gas would also probably find industrial outlets.

The retort is a mild steel drum of 5ft. diameter and 3ft. in length, lined with fire-brick and having an internal grate. The axis of the retort is horizontal, and the retort is rotated only during the carbonising periods. At the end of a carbonising period, the retort is stopped with the grate in the lowest position, and air is blown through the coke bed. A charge of about 80 lb. of coal is then added, the retort is rotated, and carbonisation is carried out by the sensible heat of the hot coke. Steam may be admitted during the last part of the carbonising period, in order to remove the residual coal gas from the retort.

With coal of a suitable nature the coke spills over automatically to a predetermined level during the rotation of the retort, but should this not occur it is blown over during the subsequent air blow, which raises the temperature of the coke remaining in the retort sufficiently to carbonise the next charge. The cycle of operations adopted during the major part of the test was as follows :—Air blowing, 1½ min.; charging, 30–60 sec.; carbonising, 4 min. without steaming, 1 min. with steaming; change over period, 30 sec.

In the experimental plant tested, this cycle is carried out without the assistance of any automatic devices, and a considerable amount of manipulation of valves, switches, &c., is necessary. It is pointed out in the Report that in a commercial plant, whether of the size tested or larger, the necessary operations could be performed by simple mechanisms, with a saving in time and in the cost of labour.

The claimed throughput of the retort is from 4 tons of coal per twenty-four hours with a strongly caking coal to 6 tons with a non-caking coal. During the test, which lasted two days, a strongly caking Durham coal was used, and the throughput was 4·1 tons per day. During this period 229 complete carbonising cycles were carried out.

Following a detailed account of the design and operation of the plant, the Report describes the arrangements made for measuring and sampling the raw materials and products, and for conducting the test. Each product was subjected to a detailed examination, the results of which are given, and the Report concludes with some general observations on the operation of the plant and of difficulties encountered during the test; the latter were mostly of a minor character.

The coal used was the undersize material from the dry cleaning plant at a Durham colliery. It was all below ⅜in. in size, and contained 2 per cent. of moisture and 8 per cent. of ash.

The coke recovered amounted to about 11½ cwt. per ton of coal charged. It was of small size, 45 per cent. passing through an ¼in. screen and 0·8 per cent. remaining on a ½in. screen. The yield of gas was 4095 cubic feet per ton of coal, with a calorific value of 799 B.Th.U. per cubic foot, or 32·7 therms of gas per ton. The tar produced amounted to 18·2 gallons per ton of coal, with a specific gravity of 1·125 at 15 deg. Cent.

THE ENGINEERS GUILD.

WE are asked to give publicity to the following statement which was authorised at a meeting of the Council of the Engineers Guild on May 26th, 1938.

The Engineers Guild was inaugurated at a meeting of engineers in Caxton Hall, Westminster, on Monday, May 16th. The objects of the Guild, as stated in the temporary constitution adopted at the meeting, are :—

> "To promote the social and economic welfare of the engineer, to stimulate public service in the profession, to encourage and develop the efficiency of the engineer, and to promote unity in the profession."

The Council of the Guild consists of fifteen members elected at the inaugural meeting with power to co-opt not more than eight additional members. It is provided that the Council must submit to a general meeting of the Guild, to be held not later than May 31st, 1939, proposals for a revised constitution and by-laws.

For the duration of the present temporary constitution, the following persons only are eligible for membership of the Guild, viz., members and associate members of—

The Institution of Civil Engineers;
The Institution of Mechanical Engineers;
The Institution of Electrical Engineers; and
The Institution of Naval Architects.

The subscription for membership of the Guild for the period ending May 31st, 1939, is £1 1s. Applications for membership and other communications should be addressed to Mr. T. W. Andrews, A.M.I. Mech. E., acting joint secretary, 68, Brooklands Park, Blackheath, London, S.E.3.

BLOWERS AND COMPRESSORS.—We are asked to state by J. Browett Lindley (1931), Ltd., of Letchworth, that standard two-stage compressors are manufactured by the firm with capacities up to 4000 cubic feet per minute, and not only up to 840 cubic feet per minute as implied by a sentence on page iv of the Supplement published with our issue of May 27th.

Rail and Road.

VISIT TO GLASGOW BY INSTITUTION OF LOCOMOTIVE ENGINEERS.—When a party of 120 engineers travelled from London to Glasgow in connection with the summer meeting of the Institution of Locomotive Engineers on Wednesday, June 8th, the London, Midland and Scottish Railway Company ran a special advance portion of the "Royal Scot." The company used one of its new 164 tons streamlined engines, the "Duchess of Gloucester" to haul the train. The opportunity was taken to give the new engine its long-distance test, and for the benefit of the travellers a dynamometer car was included in the train.

AN L.M.S. SCOTTISH LINE REOPENED.—It is announced that with the introduction of its summer timetable, on July 4th next, the London, Midland and Scottish Railway Company is to reopen the 6-mile branch line from Brechin to Edzell (Angus), from which passenger services were withdrawn in April, 1931. Other alterations will include the reopening of Foryd Station, between Rhyl and Abergele, under the new name Kinmel Bay Halt; the closing of Clifton and Louther Station, between Shap and Penrith; the renaming of Clown Station in Derbyshire to Clown and Barlborough; and the renaming of Bispham Station, between Blackpool North and Thornton as Layton (Lancashire).

SHOCK-ABSORBING RAIL WAGONS.—One hundred wagons of a special type, designed to minimise shock during shunting operations or haulage, are now being placed in service by the London, Midland and Scottish Railway Company. The building of these wagons represents the extension on a larger scale of a successful experiment made with the first shock-absorbing wagon last summer. This wagon was described in THE ENGINEER of August 20th, 1937, and in trials it was found that the special springing and buffing arrangement of the vehicle entirely absorbed normal shocks, and enabled goods to be carried by rail with added safety. The shock-absorbing wagons, which have a capacity of 12 tons, are intended principally for the conveyance of sanitary tubes, earthenware and china in crates, and similar classes of traffic.

RAILWAY STATISTICS.—Railway statistics for the calendar month of February and the four weeks ended February 19th, 1938, show that the total number of passenger journeys (excluding season ticket holders) taken on all standard-gauge railways in Great Britain in the month of February, 1938, was 90,945,200, a decrease compared with February, 1937, of 1,880,044. The journeys taken by passengers at reduced fares decreased by 1,392,404 and those at standard or ordinary fares by 487,640. If the railway undertakings of the London Passenger Transport Board be omitted, the figures show a decrease in journeys of 1,811,641 and an increase in receipts of £68,410. For the four weeks ended February 19th, 1938, the coaching train miles showed an increase of 535,382 compared with the four weeks ended February 20th, 1937. The total tonnage of freight conveyed (excluding free-hauled traffic) in the four weeks ended February 19th, 1938, was 23,898,696, an increase compared with the corresponding four weeks of 1937 of 293,532 tons. The freight train receipts amounted to £7,548,081, an increase of £149,620. The freight train miles run were 228,490 more than in the corresponding period of 1937, an increase of 2·1 per cent. The average train load increased from 131¼ to 132¼ tons and the net ton miles per engine hour increased from 457½ to 467¾.

THE NEW L.M.S. CHIEF OPERATING MANAGER.—Mr. T. W. Royle is succeeding Mr. C. R. Byrom as chief operating manager of the London, Midland and Scottish Railway Company. In his new position Mr. Royle will have under him an operating staff of 122,000, and he will be at the head of an organisation which arranges and controls the running of 16,000 freight trains and nearly 14,000 passenger trains a day. His department uses over 7600 locomotives which cover 235,000,000 miles and consume 5½ million tons of coal annually. Mr. Royle will complete forty years of railway experience in August. He started in 1898 in the trains section of the passenger superintendent's office of the old Lancashire and Yorkshire Railway, and after holding various positions at Manchester he was engaged during the war on confidential work in connection with the use of the railways for war purposes, under the Railway Executive Committee. In 1919 he became assistant superintendent of the line of the Lancashire and Yorkshire Railway, in 1922 assistant divisional general superintendent of the combined London and North-Western and Lancashire and Yorkshire Railways, and in 1923 assistant general superintendent (western division). From 1924 to 1932 he was divisional superintendent of operation, Manchester; since 1932 he has been in London, and vacated the position of chief assistant commercial manager to take up his new appointment.

RECONSTRUCTION OF L.N.E.R. CALDER BRIDGE.—During the last fortnight in June the London and North-Eastern Railway Company is to undertake the reconstruction of the bridge carrying the main line from Doncaster to Leeds over the river Calder between Sandal and Wakefield stations. This structure, officially known as bridge No. 60, was originally built in 1865. With a span of 170ft. it is one of the longest single-span bridges in the country, and its length in addition to the skew at which it crosses the river renders its reconstruction a complicated matter for the engineers. It has been the aim of the L.N.E.R. engineers to retain the lines of the existing bridge, and Dorman, Long and Co., Ltd., of Middlesbrough, have been busy for some months on the construction of the steel work for the new structure. A considerable amount of preparatory work has been carried out and the final stage of the work will take place during the period Sunday, June 19th, to Saturday, July 2nd, inclusive. Special trains conveying the sections of steel work for the new bridge, some of which will be out-of-gauge and require special working, have been arranged between Middlesbrough and the site of the work. During the period that the line is closed work will proceed day and night, and special cranes of 20 and 30 tons capacity have already been installed for the purpose of lifting out the old bridge and lifting in the new, together with special staging in the river which will support the structures during demolition and reconstruction.

Miscellanea.

EMPIRE EXHIBITION ATTENDANCE.—During the first month of the Empire Exhibition in Scotland there were over 2,000,000 visitors, the average daily attendance up to the end of May being 81,980 persons.

COAL PRODUCTION IN GREAT BRITAIN.—During the March quarter of this year 62,937,400 tons of saleable coal were raised in Great Britain. The average number of wage earners employed was 792,600 and during the three months 217 persons were killed and 855 seriously injured.

NEW THAMES VALLEY RESERVOIR.—Tenders are to be invited by the Metropolitan Water Board for the construction of a large reservoir to the south of the existing Knight and Bessborough reservoirs, at Walton. To cover an area of 374 acres, it will have a capacity of about 4400 million gallons.

A NEW DEW POINT APPARATUS.—The United States Bureau of Mines has developed a dew point apparatus by which may be determined the temperature to which a gas may be cooled before water will begin to condense. This apparatus is said to be particularly suitable for use with natural gases under pressure and is suitable for working pressures up to 2500 lb. per square inch.

AMALGAMATION OF SURVEYORS' SOCIETIES.—At the annual meeting of the Chartered Surveyors' Institution it was stated that the Privy Council had ratified the amalgamation of the Scottish Estate Factors' Society, the Faculty of Surveyors of Scotland, and the Irish Quantity Surveyors' Association with the Institution. At the meeting Sir Charles Bressey was elected President in succession to Mr. Robert Cobb.

SAFETY IN CHEMICAL WORKS.—The Association of British Chemical Manufacturers has issued Part I of a booklet on safety rules for use in chemical works. The booklet, known as "Model Rules," consists of the proposed safety rules in a concise form, and is an introduction to the second part, to be issued later, in which the procedure to be followed or advised will be described in detail. Amongst other things, the book deals with rules for the design and operation of plant with fire and explosive risks; plant involving risks from gas, vapour, fume, or dust; and plant involving dangers from contact with corrosive or deleterious substances.

MECHANISATION AND EMPLOYMENT.—An editorial in a recent issue of the *Iron Age* gives an interesting example of the relationship between mechanisation and the employment of human labour. It is taken from a ten-year record of machine employment and man-hour employment at the Titan Manufacturing Company of Bellefonte, Pa. The record begins in 1928, at which time the company had a total of 459 machines and an employment man-hour index of 130. Year by year the record shows the addition of machines, but a still more rapidly increasing rate of man-hour employment, until in 1937 with 734 machines the employment index was 483. In other words, with a 60 per cent. increase in the number of machines, the hourly employment increased 270 per cent. and salaried employment 170 per cent.

INDUSTRIAL PROPAGANDA.—The Federation of British Industries has for some time past had under consideration the question of national propaganda overseas on behalf of British industry and commerce. Industries and individual firms carry out extensive publicity on their own behalf in foreign countries, but in view of the intensive national propaganda which is being carried out by certain foreign countries in support of their commercial and industrial interests, the F.B.I. is of the opinion that some propaganda on a wider scale is urgently required. For this reason the F.B.I. has approached Sir Robert Vansittart, Chairman of the recently appointed Committee to Co-ordinate National Propaganda, in the hope that funds will be provided by the Government expressly devoted to industrial propaganda of a national character, which would not come within the province of individual industries or firms.

EARTH DAM BUILDING IN AMERICA.—An unusual method has been adopted to place the earth fill of the Quabbin dam in the United States. This dam is 2640ft. long, 170ft. high, and will contain 4,000,000 cubic yards of fill. Three borrowpits in a hillside above the east abutment of the dam are supplying the filling material. Earth is taken from the pits on belt conveyors to a central hog box, where the dry materials are mixed with water pumped up from the core pool of the dam. The mixture then flows by gravity to discharge lines along the upstream and downstream breaches of the dam. The discharge lines are built up of rubber-lined steel pipes and the material is placed in the desired positions by adding or taking away sections of pipe. The water from the mixture drains back into a pool in the centre of the fill to be pumped back into the hog box. An average of 13,900 cubic yards of material was placed daily during 1937.

CONCRETE REINFORCEMENT FOR OLD STEEL PIPE LINES.—A machine is being used in the United States for the purpose of depositing a concrete coating round old steel pipe lines which have become pitted by corrosion. As described in the *Engineering News-Record*, the concreting machine consists of a light rectangular steel frame which fits over and is supported by the pipe. Adjustable equalising dollies guide the advancing end of the machine. The frame carries a 3 H.P. petrol engine which operates a rotating steel drum surrounding and concentric with the pipe. In the rear end of the drum are bolted steel lugs which extend as spirally curved cantilevers around the pipe surface. The lugs are enclosed within a sheet steel housing which also encircles the entire pipe, and is fitted with a feed hopper. The lugs revolve within the annular space between the pipe and the housing. As concrete is fed through the hopper upon the pipe surface, rotation of the lugs forces the concrete toward their free ends and in so doing builds up a pressure which increases until the entire apparatus rolls along the pipe away from the compacted concrete. The speed of travel is controlled by the rate at which material is fed into the hopper, and as it moves along the machine leaves behind it a finished concrete encasement which has been compacted and firmly pressed against the entire pipe circumference.

Air and Water.

THE FIFTH SEA LORD.—It is announced by the Admiralty that the appointment of Vice-Admiral Sir Alexander Ramsay as a Lord Commissioner of the Admiralty and Chief of Naval Air Services, in succession to Rear-Admiral John H. D. Cunningham, will take effect to date July 19th, 1938.

NORDDEUTSCHER LLOYD AND ANTWERP.—It is announced that the Norddeutscher Lloyd ships "Scharnhorst," "Gneisenau," and "Potsdam," which carry cargo and passengers to the East Indies and Far East, will no longer call at Antwerp. Their port of call is to be Rotterdam in the future.

A PROPOSED MINISTRY OF SHIPPING.—The annual report of the Officers (Merchant Navy) Federation recommends the setting up of a Ministry of Shipping. The Minister of Shipping, with Cabinet rank, would be solely concerned with the protection and development of British shipping in the nation's interest, with due regard to the interests of shipowners and the personnel of ships.

THE GUGGENHEIM GOLD MEDAL.—The Guggenheim Gold Medal for 1938 has been awarded to Mr. A. H. R. Fedden, chief engineer of the aero-engine department of the Bristol Aeroplane Company, Ltd. The Daniel Guggenheim Fund for the Promotion of Aeronautics was formed in January, 1926, and in 1928 the fund allotted a sum for a medal to honour notable achievements in the advancement of aeronautics.

PANAMA CANAL.—Reports state that the United States Government is debating whether the Panama Canal should be enlarged or another Central American Canal should be constructed. The new canal would join the Atlantic and Pacific coasts through canals to a natural lake in Nicaragua. Estimates have shown that to enlarge the locks of the Panama Canal would cost 200 million dollars, whereas the new canal would cost 722 million dollars to build.

THE MECHANISATION OF THE ROYAL NAVY.—An exhibition illustrating the mechanisation of the Navy has been arranged at the Royal United Service Museum in Whitehall. This exhibition comprises a number of models, drawings, and photographs depicting the introduction and progress of propelling machinery and the development of artillery and torpedoes. A case of models shows the latest types of special aircraft being used by the Fleet.

ISLE OF MAN AIR RACE.—The race from Hatfield to the Isle of Man on Saturday, June 4th, was won by Mr. S. T. Lowe, in a "Comper Swift" in 2 h. 55 min. 28 sec., at an average speed of 159·5 miles an hour, his flying time being 1 h. 51 min. 21 sec. The second place was taken by Mr. A. Henshaw, jun., in a Percival "Mew Gull" in 2 h. 56 min. 30 sec., and the third place by Flight-Lieut. H. R. A. Edwards in an Aero "Avian" in 2 h. 57 min. Mr. Henshaw won a special prize for the fastest flying time of 1 h. 11 min. 41 sec., at an average speed of 247·5 miles an hour.

A NEW L.M.S. CLYDE SERVICE.—In connection with the Empire Exhibition at Glasgow, the London, Midland and Scottish Railway Company has inaugurated a daily service of motor cruises on the Clyde. Two new boats, accommodating 100 passengers, have been built for this service by Wm. Denny and Brothers, Dumbarton, and they will provide a series of short cruises both on week-days and Sundays during the Exhibition period. These cruises will start from Bridge Wharf, Glasgow, and will proceed down river to a point a short distance beyond John Brown and Co.'s shipyard at Clydebank, giving passengers a view of the new Cunard-White Star liner now under construction, as well as of Clyde shipping and shipyards generally.

A HARBOUR SCHEME FOR NORTH CHINA.—A note in the *Shipbuilding and Shipping Record* says that a plan for port and harbour construction in North China, to be undertaken by the projected China Communications Company, is being studied by Japanese authorities there. The proposed company, like the South Manchuria Railway Company in Manchukuo, would undertake the project directly, in addition to the control and management of all railways in North China. The principal ports in that region are Tientsin, including Tangku, Chinwangtao, Tsingtao, and Lienyun, near Haichow. With prospective enforcement of a North China four-year plan, harbour construction on a large scale will be necessary. The enterprise is believed to be necessary in connection with railway construction. An enormous amount of capital will be required for achievement of this enterprise. For the time being therefore the work will be confined to enlarging existing equipment. Work is expected to be completed during 1940.

SLEEVE VALVE AERO ENGINES.—The Bristol "Perseus" XII.C sleeve valve aero engine, which has been specially developed for commercial transport use, has a bore and stroke of 5¾in. and 6¼in., and a cubic capacity of 1520 cubic inches (24·9 litres). The "Perseus" XII.C has successfully passed its type test and has been accorded the following rating:—Take-off (maximum): Power, 900 B.H.P.; speed, 2700 r.p.m.; boost, +3 lb. per square inch. International rating: Power, 680–710 B.H.P. at 4000ft.; speed, 2250 r.p.m.; boost, +1¼ lb. per square inch. Maximum level flight (5 mins.): Power 815 B.H.P. at 6000ft.. speed, 2600 r.p.m.; boost, +1¼ lb. per square inch. Imperial Airways, which has already had considerable experience with Bristol sleeve valve engines, has decided to equip a number of its Empire flying boats with "Perseus" XII.C engines, and it has already been announced that these engines will be used in the new D.H. type 95 high-speed twin-engined transport monoplane. The Bristol "Perseus" X is a fully supercharged sleeve valve aero engine, intended mainly for high-altitude, high-speed, fighting aircraft. It has successfully passed an official type test and been accorded a maximum power rating of 880 B.H.P. at 15,500ft. In addition to the unusually high power developed at altitude, the "Perseus" X has excellent take-off characteristics, giving 750 B.H.P. at 2650 r.p.m., with a boost of +3 lb. per square inch. These engines are now in regular quantity production, and have been scheduled for a number of the latest production type aircraft of the Royal Air Force, as well as many new prototypes.

SINGLE STAND 105-TONS PER HOUR CAPACITY BLOOMING MILL

(*For description see page 658.*)

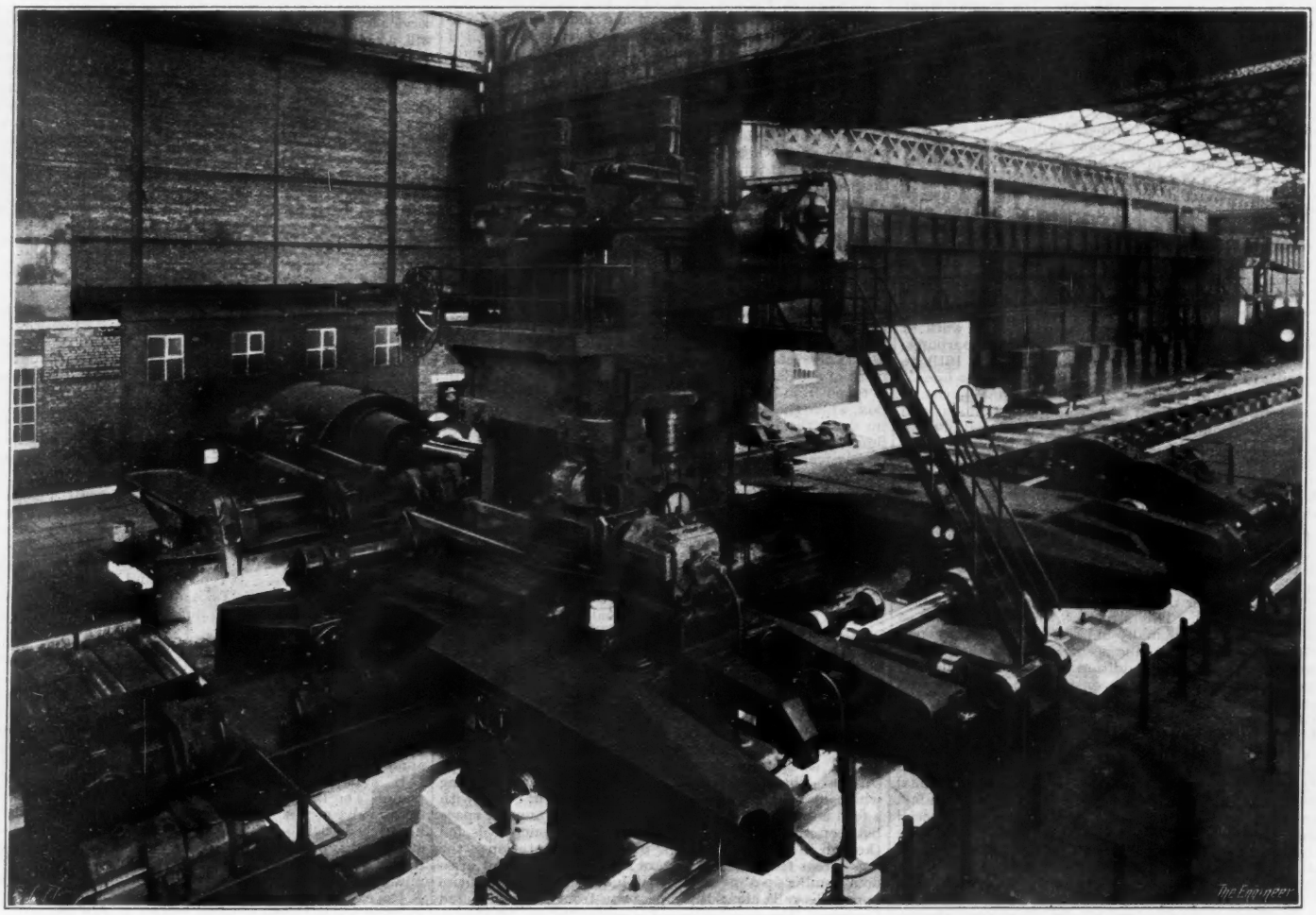


FIG. 9—MANIPULATORS AT BACK OF MILL

FIG. 10—MANIPULATORS AT FRONT OF MILL

The Engineer

JUNE 10, 1938.

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NOTICES TO READERS.

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**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

**** Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

COFFEE AND PISTOLS.

ALL engineers whose memories carry them back to the beginning of the century and a little further will recall the animosity which then too often prevailed between the trade unions and the employers. It is not for us at this time to condemn that animosity. Looked at philosophically, it was a natural and inevitable condition. Victorian industrialism assumed that the employer was the complete "master" of his own affairs, and it regarded the individualism of the workmen as a desirable virtue. Collective bargaining existed to a certain extent, but there were many opponents, not only amongst the employers, but amongst the employed. In those days works were generally dominated by a single personality, who insisted upon exercising all the powers of an autocrat. Like the modern autarchy of nations, the system had its good points; it had also its bad ones. But bad or good it was the inevitable outcome of its precedents. There is, we believe, little or no evidence that it led to gross abuses in engineering works, as it did in textile and other factories. But engineering was embraced in the changes that were taking place, and step by step unified labour was undermining the individualism of workmen, and the collective bargain was taking the place of the personal contract. In such circumstances friction was unavoidable; it is no more blameworthy than a physical phenomenon. The employers firmly and honestly believed that it was best for all parties that they should be the "masters." The workers, on their side, resented a condition which was akin to "serfdom." Hence whenever trouble broke out there were two sharply defined parties. Traces of that feeling remained up to thirty years ago—and it must be admitted still obtain with many workers—but by degrees it began to be recognised that the employers and the employed formed, not two opponents, but one party in a great industry. That position having been reached, a spirit which encouraged conciliation and agreement rather than recalcitrance and hostilities arose. That spirit has gained in strength year by year until it has become a great power for peace in the engineering industries. It would be difficult to over-estimate the magnificent work, begun by George Barnes and carried on by his successors for engineer employees, on the one hand, and the wise policy, of the federated employers, on the other. Between them they have controlled the hotheads in their parties and have so directed their efforts towards the common good that a strike of national dimensions in the industries concerned has become an improbability.

We could ask for no better evidence of the present spirit than Mr. J. C. Little's handling of a difficult situation at the Morecambe meeting last week of the National Committee of Amalgamated Engineering Unions. Mr. A. Dalziel, of Glasgow, moved that the Employers' Federation be approached with a demand for an increase of 3d. per hour in wages and that a time limit be set for the concession of the demand. If the increase were not given by the beginning of August then a ballot was to be taken for a strike to enforce it. Mr. Little, the President, showed first that the power of the employers to pay so large an increase was not as great as it appeared to Mr. Dalziel, and those who supported him. He then said—we quote from *The Times* of June 2nd:—"If they held the pistol of a strike ballot at the heads of the employers, instead of taking the ballot on an offer for an advance in wages, they would probably be considering strike action in order to force the employers to make an offer. The whole thing was ridiculous. If the employers acted as they had in the past, instead of being able to get to grips with them immediately to extract an offer from them, the form in which this was presented would in all probability prevent any discussion taking place at all. The prospect was that what they would be balloting on would be the refusal of the employers to discuss the question of an advance in wages until this pistol was removed from their heads." Ultimately a resolution was agreed to, but only by a narrow majority, that the Federation should be approached without any time limit being mentioned. The episode illustrates the point we have been endeavouring to make. On the one side we see the old-time method of a pistol at their heads, and on the other the method of consultation over the coffee cups. The latter won, as it has so generally done in recent years, and we may take it for a certainty that all the details of the arguments on both sides will now be thrashed out at a conference between the A.E.U. and the Federation. The pistol having been returned to the holster, or never drawn out of it, we may feel assured that both parties will meet, not in a spirit of opposition, but with a single desire to achieve the best result for the industry.

May we suggest to the A.E.U. that, in pursuance of the policy of sweet reasonableness, which to its great honour it has adopted, it should discourage the use of a word which by definition is a negation of that policy? We refer to the word "demand," so common in labour circles. It means to ask for something "peremptorily"; a pistol-at-your-head word. The kind of word the tax collector and the highwayman may use, but not the word one employs in the settling of a bargain. It implies a sort of threat, a power to coerce the other party into concession. Not a conciliatory word; not a word of good feeling. Not a word that is likely to lead to an issue happy to both parties. Even when all allowance is made for the looseness with which it is, no doubt, often used, it retains a psychological effect. "Claim" is a better word in this connection, and we note with pleasure that it was used in the amendment adopted at Morecambe. One may ask for a "claim" to be considered, but a "demand" leaves no room for consideration. Would it not be more in accord with the spirit of friendly agreement if "demand" were deleted from the trades union vocabulary? A claim disallowed after amicable debate leaves no rancour; a "demand" rejected always implies defeat and must cause a little soreness. The Federation and the unions are not out, nowadays, thank Heaven, to measure their respective strengths, but to endeavour by logical argument to reach conclusions best for both.

Trends in Power Station Practice.

BY far the most important paper of an engineering nature presented at the recent I.M.E.A. Convention held at Torquay was that by Messrs. H. C. Lamb and K. Baumann on "Present-day Trends in Power Station Practice," published in abstract in our last issue. Based to a large extent on observations which the authors made in America in 1936, and particularly during visits arranged in connection with the World Power Conference, it throws considerable light on the efforts made by engineers to generate cheap electricity. The highest thermal efficiency obtained in any existing power station is shown to be 31·5 per cent., which is the figure reached on the units sent out by the 85,000-kW Port Washington plant having one boiler per turbine and belonging to the Milwaukee Electric Railway and Light Company. Steam is generated at 1230 lb. per square inch superheated to 825 deg. Fah., and is reheated to that temperature at a pressure of 425 lb. per square inch at maximum capacity. Fuel costs per unit sent out are 0·080d.; working costs, excluding fuel, 0·023d.; capital charges based on 15 per cent. for interest and depreciation, 0·165d., giving a total of 0·268d. per unit. The fuel costs it will be observed, are only 30 per cent. of the total, while the capital costs are 61·5 per cent., the capital costs per kilowatt installed being £22, including land, coal, dock, and storage for the completed station, with a probable ultimate capacity of 400,000 kW. When the station contains that amount of plant, the figure of £22 is expected to be reduced to between £15 and £16. At present the plant does not appear to show a better final result than that obtained in this country with less ambitious steam conditions, although it is to be noted that 15 per cent. for interest and depreciation is high compared with British practice. Mr. P. J. Robinson, the Chief Electrical Engineer at Liverpool, explained in the discussion, which we report to-day, that the results compared favourably with those at Clarence Dock, notwithstanding the difference in design; in fact, assuming the same capital charges, the total costs for the two stations would be exactly the same. The capital charges of 15 per cent. at Port Washington are much higher than at the Liverpool station, which has sufficient land and the necessary buildings for extensions to 400,000 kW. On the first 100,000 kW of plant with a steam pressure of 400 lb. per square inch, the net fuel cost, including handling and credit for the sale of ashes for 1936, was 0·106d. per unit sent out compared with 0·08d. at Port Washington, but the figures for the total cost per unit sent out including capital charges were 0·202d. at Clarence Dock and 0·268d. at Port Washington.

With the practice of employing one boiler per turbine Mr. Robinson appears to have little sympathy, notwithstanding that according to Messrs. Lamb and Baumann's paper, the saving in capital cost by using one unit instead of two was £62,500, or 16s. 8d. per kilowatt of capacity. While one boiler per turbine may be going to the extreme, there is no doubt that there is much to be said for large steam-raising units on the score of economy. In his Presidential Address to the Junior Institution of Engineers in 1931, Sir Leonard Pearce, then Dr. Pearce, explained that Dr. Munzinger, the leading authority on boilers in Europe, had stated that the construction of boilers having very high capacities was the most effective means existing for achieving reduction in cost of plant and the cost of generation, an expression of opinion which had been largely verified in the United States. Hence the tendency to reduce the number of boilers or even to adopt one boiler unit per turbine. The new boiler Sir Leonard is about to install in the Battersea power station exemplifies the large unit policy. It will have a maximum continuous rating of 500,000 lb. per hour and a normal economic rating of 440,000 lb. when generating steam at 1420 lb. per square inch and at 965 deg. Fah. at the superheater outlet from feed water at 400 deg. Fah. Incidentally, since the combination of high pressure and such high temperature has never before been attempted, the design of the boiler will prove interesting, especially as there are no available standards applicable to the conditions involved. The new boiler is the first of a pair which will ultimately serve the 100,000-kW plant ordered last August and when operating alone at its maximum rating will enable the turbo-alternator to generate about 65 per cent. of its maximum continuous output. But as the second portion of the generating set can take steam from the existing mains in the station in addition to the exhaust steam from the primary turbine, with only one boiler installed, the new 100,000-kW plant will be able to operate up to 95 per cent. of its maximum continuous rating. The London Power Company is also leading the way in the use of large forced circulation boilers with which Mr. Robinson also finds fault. By the

installation of the 350,000 lb. per hour La Mont boiler working at a pressure of 375 lb. per square inch in the Deptford West power station, it will, when the job is completed, have won the distinction of using the largest boiler of the kind in the world, and will have obtained the advantage of a steaming capacity of about three times that of natural circulation boilers originally erected in the space the La Mont unit is to fill.

Nothing that has been done in America puts British practice in the shade, but owing to special circumstances more attention has been paid in that country than in Great Britain to superposed plants, which, according to the American definition, are extra high-pressure installations superposed on existing plant to postpone the obsolescence of the latter without introducing reheating. The principle is far from new, but the retention of old plant differentiates the scheme from that of using new condensing low-pressure turbines as in the cases of the Brimsdown and Battersea extensions. Conditions for superposed plants are more favourable in America than in Great Britain, because for 60 cycles a higher speed turbine can be used. In this country the highest speed permissible for a non-geared turbine is 3000 r.p.m., which results in greater cost. Superposition is particularly favourable where further cooling water for condensing is difficult to obtain and where the existing plant operates at comparatively low pressure, such as 300 lb. per square inch or lower, provided that the low-pressure plant has considerable life. On the electrical side this country has led the way in the construction of large alternators generating at 33,000 volts. Since the first Parsons machine working at this pressure was installed at Brimsdown practically all the large British electrical firms have developed machines of this kind, whilst in America alternator pressures have not exceeded 22,000 volts. As reported in THE ENGINEER of February 25th of this year, hydrogen cooling is being applied to American generators which are built for outputs as high as 60,000 kVA at 3600 r.p.m., but so far this practice has not been deemed to be necessary on 3000 r.p.m. British-made machines, although hydrogen cooling may be advantageous, in the way of reducing corona, if generators are built for still higher voltages. The design of modern power stations embraces such a wide variety of mechanical and electrical problems that the paper discussed necessarily only contains a summary of the more important. Changes in steam and electrical practice, since the public supply of electricity began, have exceeded by far the pioneer's wildest dreams, but since a thermal efficiency of 31·5 per cent. is the maximum that has been realised and the cost of some of the equipment leaves much to be desired, no one believes that a state of finality has been attained.

Institution of Mechanical Engineers.

CARDIFF SUMMER MEETING.

No. II.

(*Continued from page 617, June 3rd*).

THOSE who have never visited Cardiff commonly imagine it to be a smoke-begrimed town too immersed in the mining of coal and the manufacture of iron and steel to find time and opportunity to cultivate beauty and the higher values of civic life. The newly arrived visitor bearing such a preconception is speedily and pleasantly disillusioned. It is true that it is a great coal-exporting centre and that its dockside area, with its extensive system of sidings, its steel works, its flour mills, timber yards, and power stations, reproduces the strictly utilitarian features to be found in most British ports. Full compensation for the æsthetic eye is, however, to be found in the central area of the city. Here the visitor will discover many noble vistas and many fine buildings, both ancient and modern, grouped in a spacious dignity and exciting the admiration of all who see them. In a dominating position stands Cardiff Castle, one of the seats of the Marquis of Bute. This structure, dating from early Roman days, added to by the Normans, and extended and altered in succeeding centuries, provides the origin of the city's name, Caer Taff—the castle on the river Taff. The castle is strung along part of one side of a four-square walled enclosure. On a moated mound within stands a twelfth century keep, while outside the busy traffic of these modern days flows noisily past the walls. Arranged in fair perspective with the castle is a large area intersected by tree-lined avenues. Here there are grouped in conformity with a grand general scheme the city's public buildings—the City Hall, the County Hall, the Law Courts, the National Museum of Wales, the University College of South Wales and Monmouthshire, the Technical College, and the offices of the Welsh Board of Health. In a central grass-swarded area stands the Welsh National War Memorial, and in a corner lies a Temple of Peace. All these buildings represent modern architecture at its best. They blend harmoniously with each other and with the ancient castle in the background.

Disillusioned as to the imagined grimy sordidness of Cardiff, the visitor, if he explores its immediate neighbourhood, will find it difficult to believe that it lies anywhere near a great coal-mining district. The coal mines lie in the valleys behind the city and do not intrude themselves upon the fair scenery of the surrounding countryside. The truth is, as one speedily discovers, that Cardiff, although one of our greatest coal-shipping ports, is sufficiently remote from the coal-mining areas to free it completely from the ugliness which inevitably accompanies the industry on which it is so largely dependent.

As a centre for the summer meeting last week of the Institution of Mechanical Engineers, Cardiff provided all the main essentials for success except one. It gave the Institution and its genial President, Mr. David E. Roberts, a warm welcome and generous hospitality. Its hotel accommodation was ample. It provided a wide selection of interesting visits to works and technical establishments, and, within easy reach of it, it afforded numerous objects of historic, archæologic, and romantic interest to beguile the members' less serious moments. In one respect only did it disappoint; if the rain ceased at all during the first three days, it was only to gather fresh force for a renewed downpour. The fourth day, however, and at least part of the fifth, were resplendent with sunshine and helped the visitors to forget the dampness of the earlier part of the week. In any event, the organisation of the Institution's summer meetings is so near perfect as to be weatherproof, and not once did we observe the inclement meteorological conditions affecting the spirit of the Cardiff meeting. It was particularly regretted that the weather was at its worst on Wednesday afternoon during the garden party at the castle. A little warmth from the sun on that occasion would doubtlessly have been welcomed by all. In the continued absence through ill-health of Brigadier-General Mowat, the burden of the Secretary's duties was ably borne by Mr. J. E. Montgomrey, who, with the assistance of Mr. F. W. White and other members of the Institution staff, attended with unfailing courtesy to the communal and individual arrangements of the 340 members and ladies taking part in the meeting.

The programme broke with tradition in so far that it began officially on Monday afternoon instead of on Tuesday morning. At 4 o'clock the President, Council, members, and ladies were welcomed to the city by the Lord Mayor, Alderman O. Cuthbert Purnell, the Lady Mayoress, and the members of the Cardiff Reception Committee. The ceremony took place in the meeting hall of the South Wales Institute of Engineers, to the Council of which body the Institution owes more than formal thanks for allowing its building in Park-place to be used throughout the week as the official headquarters of the meeting. In the evening the Monmouthshire and South Wales Coal Owners' Association entertained the visitors to a dinner and dance in the City Hall. The guests were received by the chairman of the Association, Mr. F. H. Davies, and by Mrs. Davies. The dinner was held in the Assembly Room, an imposing chamber which suffered from but two defects—inferior acoustics and a very slippery floor. The hospitality afforded on this occasion was a foretaste of that which was to be experienced later wherever the members went and demonstrated unmistakably that South Wales, although hit hard by trade depression, takes a brave pride in honouring the stranger from across the border. Equally, too, was it apparent that in Mr. David Roberts, a Welshman born, the Institution has a President of rare honour in his own country.

On the morning of Tuesday, May 31st, while the ladies visited the National Museum of Wales, the members assembled in the hall of the South Wales Institute of Engineers for the presentation of a paper by Mr. W. F. Cartwright on "The Design and Operation of a Modern Blooming Mill." This paper, of which a reprint in full was begun in last week's issue and is continued in to-day's, describes in detail the rolling plant recently installed at the Guest Keen Baldwins Cardiff works. On all hands we heard the paper described as a valuable practical contribution to the Institution's "Proceedings." Unfortunately time did not permit of its being discussed.

The customary panoramic photograph of the members and their ladies had to be omitted on account of the rain. While a small party proceeded to Newport to visit the Courtybella works of the Whitehead Iron and Steel Company, a large party adjourned to the City Hall, where, joined by the ladies, we were entertained to lunch by the Guest Keen Baldwins Iron and Steel Company. This lunch will long remain in our memories, not only for its good cheer, but for its accompaniment, the singing of the Dowlais Works Choir. Repeatedly during the meeting the members were to be reminded that the Welsh are by nature a highly musical folk. On this occasion the singing of the forty men from Dowlais charmed the audience to such an extent as to interrupt the luncheon proceedings. Universal regret was expressed that the stirring songs sung by the choir had perforce to be accompanied by the rattle of knives and forks and coffee cups. Following the luncheon the majority of the ladies proceeded on a short motor tour to Llandaff Cathedral and St. Fagans Castle. A few, braver perhaps or more technically minded, accompanied their menfolk to their hosts' Cardiff works, where the plant described by Mr. Cartwright in the morning was seen in operation.

All parties united for tea at the University College of South Wales, where they were received by Principal J. F. Rees, and members of the professorial staff, and were later afforded an opportunity of inspecting this fine example of a modern university building. The day was concluded with a reception and dance in the City Hall, to which the visitors were invited by the Lord Mayor and Lady Mayoress, on behalf of the City Council.

On Wednesday a party left Cardiff on a whole-day visit to Ebbw Vale, where the steel works of Richard Thomas and Co. were inspected. Other parties spent the morning in Cardiff or its neighbourhood. One of these parties visited the wire rope works of D. Morgan Rees and Sons, and another made a tour of the Great Western Railway Company's Cardiff docks. A third party inspected Messrs. Spillers' dockside flour mill, while a forth visited the South Wales and Monmouthshire Trading Estate at Treforest, where the establishments of British Coated Board and Paper Mills, the South Wales Electric Power Company, the Treforest Chrome Leather Works, and Treforest Mouldings were inspected. In the afternoon these various parties reunited and attended a garden party at Cardiff Castle. The occasion was graced by the presence of the Earl and Countess of Dumfries. In the evening the Institution dinner was held in the Assembly Room of the City Hall. Over four hundred and twenty members, ladies, and guests attended the function. The toast list and the speeches were commendably short. "The City of Cardiff" was proposed by Mr. H. L Guy and responded to by the Lord Mayor, and "The Institution of Mechanical Engineers," proposed by Mr. D. Morgan Rees, was replied to by the President. Following the dinner there was a dance until midnight.

On Thursday, June 2nd, all the members and ladies travelled by special train to Neath. At that town they split up into a number of parties for the purpose of visiting a number of industrial establishments. One party inspected the Eaglebush Tinplate Works and the works of the Metal Box Company, while another proceeded to Llandarcy to visit the Anglo-Iranian Oil Company's refinery. A third party went to the Albion Steel Works of the Briton Ferry Steel Company, and a fourth journeyed to Clydach to inspect the nickel refinery of the Mond Nickel Company. A fifth party visited the Tir John Electricity Works of the Swansea Corporation. In the afternoon these different parties reassembled at the Swansea Civic Centre, where they were received by the Mayor of Swansea, Councillor W. D. Rees, and entertained to tea. At Swansea we found, as at Cardiff, that the civic buildings had been erected in a manner and on a scale of much grandeur. There is, we believe, great rivalry between the two cities. We will do nothing to exacerbate it and will content outselves with remarking that if the Cardiff city hall excels in the beauty of the statuary with which it is embellished, its counterpart at Swansea is equally distinguished by its Brangwyn frescoes and its magnificent Australian walnut panelling.

Leaving Swansea by motor coach, the visitors drove along the beautiful Gower coast to Rhossilly and then turning back arrived at Langland Bay Hotel, where they were received by Mr. Cecil F. Gilbertson, Chairman of the South Wales Siemens Steel Association, and Mrs. Gilbertson. As guests of that Association the members and ladies were entertained to supper and an informal dance. Later the party returned by coach to Swansea and thence by special train to Cardiff.

The concluding day, Friday, was, as is customary, devoted to all-day tours to places of interest other than technical within comfortable reach of Cardiff. There were two such tours. The larger party elected to go on an excursion up the Wye Valley. In the forenoon this party halted for an hour at Tintern and studied the ruins of the Cistercian Abbey, under the able guidance of Mr. A. J. Taylor, Assistant Inspector of Ancient Monuments for Wales. After luncheon at Sedbury Park the party continued on through Monmouth and thence to Raglan, where a pause was made

for tea and an inspection of the historic ruins. Raglan Castle is of particular interest to engineers because within its walls the Earl of Worcester erected his famous "fire-engine" for the purpose of pumping water from the moat. The visit on Friday was saddened by the sight of the castle flag flying from the keep at half-mast. It announced the death on the previous day of Mr. Raglan T. H. Somerset, the Warden of the Castle, who had arranged to show the party over the ruins every stone of which was known to him. Following a short call at Caerleon, where the recently excavated remains of the Roman amphitheatre were seen, the visitors returned to Cardiff.

The other and smaller party left Cardiff in the s.s. "Britannia," and crossing the estuary of the Severn, landed at Minehead. Following lunch the party proceeded by motor coach to Lynmouth by way of Porlock. The return journey to Minehead was made across Exmoor and by way of Exford and Wheddon Cross.

Thus concluded the Institution's fourth visit to Cardiff. The third was paid in 1906 and was a notable one in the Institution's annals. We cannot believe however, that it could have surpassed the visit of 1938 in any respect and especially in the warm-hearted and generous welcome offered to the visitors by their Welsh hosts. Geniality and good friendship radiated downwards from the President, and, in spite of the unfortunate weather conditions at the start, pleasant recollections of the meeting will long be preserved by all who took part in it.

Literature.

The Construction of Main Sewers, including the Timbering of Excavations. By C. G. KENT, M. Inst. C.E., assisted by J. C. MORRIS, B.Sc. (Eng.), Assoc. M. Inst. C.E. London: Longmans, Green and Co. 1937. Price 25s.

THE dispositions and operations necessary to the successful carrying out of main sewers construction are so numerous and various, and involve so many contacts with existing constructions and with traffic, that the subject suffices to fill a volume such as that which Mr. Kent has prepared, containing 286 pages of large print, 184 figures, and 31 photographs (plates). Owing to the small dimensions of a sewer cross section or its trench or tunnel, the figures, although drawn to a relatively large scale, do not unduly reduce the space available for the text, and consideration of the various parts of the book leads to the conclusion that it is of very suitable length for adequate treatment of the subject, it being understood that it is one of the class usefully confined to description and discussion of organisation and methods, and does not include a review of practice with discussion of named works. The author explains, in his preface, that the experience upon which the book is based was largely gained from work on the Manchester main drainage scheme. The portion dealing with timbering is a reproduction, with some additions, of the author's article on "The Timbering of Trenches, Shafts, and Tunnels," published in THE ENGINEER, July 23rd, 1926, since when timbering practice has changed but little, if at all. The book has been written therefore in the light of present practice, especially as exemplified by the very extensive surveys, setting out, and constructions under various and often difficult conditions of ground and surroundings in the Manchester drainage area.

The book is well planned, the entire series of operations of surveying, setting out, and construction being described with respect to sewers in tunnel in Chapters II to X inclusive; which are followed by chapters covering the construction of sewers in open cut; methods of dealing with water; special work; shield tunnelling; blasting; ventilation; records; and tools and plant. The last two chapters of the book are devoted respectively to timbering trenches and shafts and timbering tunnels. The illustrations are well chosen and very well drawn, and most of the photographs usefully depict stages of construction of a sewer or features of temporary works and plant. Some disappointment may be felt with regard to the brevity of the first chapter, only eight pages having been allotted to a general discussion of organisation of work, nature of ground, and considerations influencing choice between open cut and tunnel. The quality of the discussion in this chapter is such that fuller treatment of the first two of those subjects, allotted less than 4½ pages, would have been welcome. The series of chapters on construction of sewers in tunnel begins with a short but adequate chapter on the spacing and siting of shafts and the examination of buildings and road surfaces. The author next describes setting out on the surface, with full information as regards the surveying operations involved. Having regard more especially to the extent to which the book will be consulted by municipal engineers, and used by their assistants during the setting out and execution of works, the full exposition of surveying operations, the chapter on transferring lines and levels down shafts, and the elementary geometrical matter relating to the setting out of curved lengths of brick sewers could not suitably have been covered by references to the literature of surveying and tunnelling. In any case, the space saved would not have been worth the inconvenience. This consideration applies to other parts of the book, the authors' consistency in this regard having given it the character of a work complete in itself. The balance of the volume is good, not only as regards the main divisions of the subject, but also with respect to the consideration given to different aspects of dispositions and the various materials and methods of construction; as in the chapter on "Shafts," in which advice is given as to their equipment and sizes, their position in relation to the centre line of the sewer, the lengths of base lines, sinking operations, also, as demanding attention at the same stage in the operations as a whole, the arrangement of yards. Again, the chapter on the construction of brick sewers is followed by one on the subject of normal routine in driving and lining, in which are furnished particulars relating to sewers of 12ft. and of 7ft. 9in. diameter, with rates of progress and compositions of the gangs, similar information being furnished with respect to small brick sewers in tunnel. As to construction with concrete laid in place, the author observes that sewers of large and medium size are sometimes so constructed, enumerates what he regards as the five most important disadvantages of that form of construction, and (quite acceptably) leaves it at that. He explains that curved, precast concrete blocks are sometimes used, one type as a lining backed by common brickwork, another instead of cast iron segments and a third type or suitable size, in the same manner as in brickwork construction. The well-illustrated chapter on curved lengths of brick sewer in tunnel is followed by a description and discussion of the laying of pipe sewers in tunnel, and the series relating to tunnel work concludes with a chapter on construction under compressed air. Of the remaining chapters, it is sufficient to note that the parts of the subject, hereinbefore mentioned, to which they relate are handled with the same awareness of what is essential or may usefully be included.

Accordingly, the book provides thorough description, adequate discussion, and useful recommendations as regards dispositions and procedure. By confining his work to consideration of main sewers, Mr. Kent has been able, in a book of convenient size, to include in his treatment of the various parts of the subject consideration of every essential aspect of the planning and execution of the work itself, in regard to the design of which existing literature is ample. As he observes in his preface, the methods described are, of course, capable of modification or extension to suit special cases and circumstances; which will be well understood by the many engineers who will find the book of service; while teachers will appreciate a volume which, being complete in itself, will serve as a text-book of clearly defined scope, and in a wider aspect be instructive as regards the organisation and conduct of operations in many respects typical.

Waterworks for Urban and Rural Districts: Including the Supply for Isolated Dwellings. By HENRY C. ADAMS. Third edition. London, 1938: Sir Isaac Pitman and Sons, Ltd. Price 15s.

APART from the consideration that a second edition of this useful work was published in 1931, the sixteen years that have elapsed since the appearance of the first edition have not been marked by any development in practice other than such as could readily be dealt with in the revision. The author explains in his preface that he has made no material alteration, but, besides incorporating new matter where necessary, has omitted some portions rendered of less importance by the lapse of time. That operation is not performed as often as it should be, even when, in their revising of technical books, authors supply new material which should replace, rather than be added to, some of the original passages. The value of Mr. Adams' work is largely due to the soundness of his judgment in planning it. All essentials of the subject of water supply are adequately presented, and provisions as regards pumping, reservoirs, and the distribution system are dealt with; fully with respect to rural supplies, as they are provided by water engineers, and as fully as will usually suffice in the case of the supply of a small town or a larger one of ordinary character. In the case of a large urban district presenting some of the more difficult problems, or requiring elaborate dispositions, it may, of course, be necessary to supplement the information furnished in this book by reference to other works. The author has, in some 250 pages and with 114 illustrations, covered the ground from the watershed to the water butt, and has presented all essential information in regard to qualities and quantities of water. Discussion of the problem of rural water supply does not come within the scope of the book, but a number of passages bear usefully upon aspects of that problem.

The proper uses to which the book may be put must be considered in the light of the fact that it is seldom expedient that works of water supply should be carried out without the aid of a fully qualified engineer. There are, however, many engineers whose qualifications are such that a suitable book is necessary as an aid to their designing and carrying out works of the classes described in this volume, without which and in default of other adequate inspiration and guidance, some of them would execute needlessly costly works and others would fail suitably to exploit the available sources. Moreover, in the hands of a competent engineer, the data and the designs which Mr. Adams places at his disposal in one small volume may be of considerable help in the designing of a water supply. More important, however, is the educative value of the book, whether used for the instruction of students or by junior engineers when first taking up the subject of water supply engineering, for although, as regards that subject as a whole, the value of other treatises and the necessity for their eventual study must not be overlooked, Mr. Adams' well-arranged exposition is of such a character that the student can profitably use it, as a whole or part by part, in conjunction with works relating more fully to several aspects of the subject or to subjects fundamental in regard to it, such as rainfall and run-off, underground water, the designing of dams, and town planning.

BOOKS RECEIVED.

The Organisation of Research in a Works. London British Chemical Plant Manufacturers' Association, 160 Piccadilly, W.1. Price 1s. net.

Costs and Tariffs in Electricity Supply. By D. J. Bolton, M.Sc. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 12s. 6d. net.

Handbook on Ventilation: Including Air Conditioning. By P. L. Marks. London: Technical Press, Ltd., Ave Maria-lane, E.C.4. Price 7s. 6d. net.

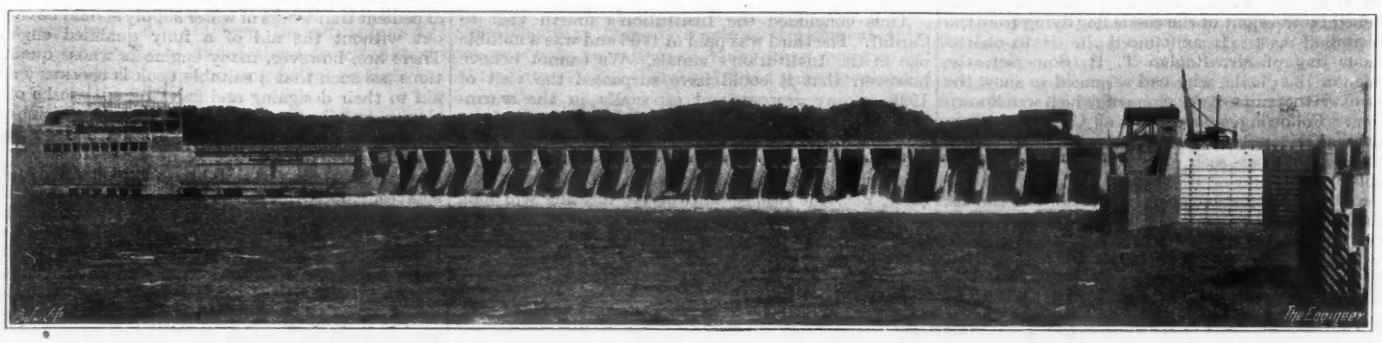
Practical Methods for Depreciation of Factory Equipment. By F. W. Gordon. London: Arthur H. Stockwell, Ltd., 29, Ludgate-hill, E.C.4. Price 3s. 6d. net.

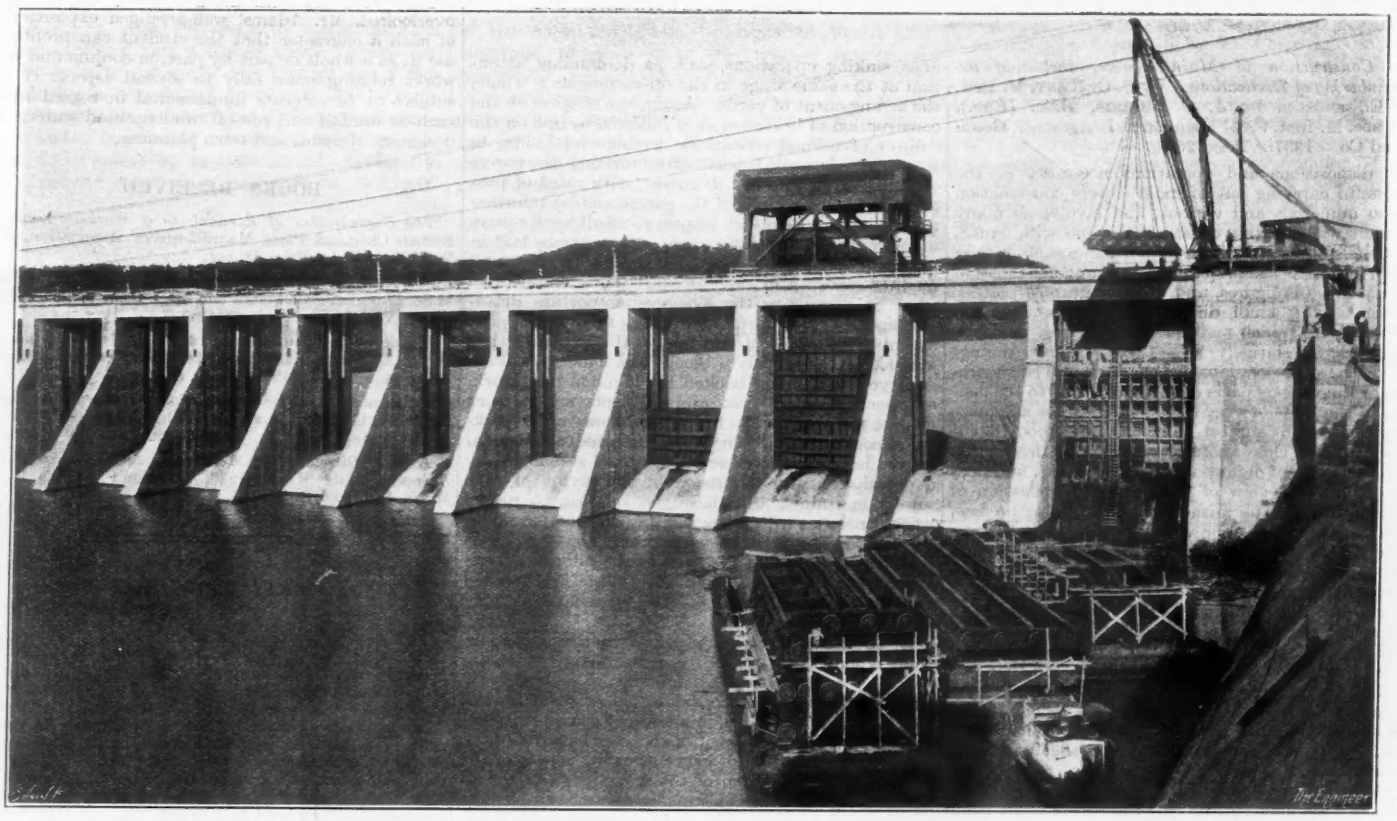
Kelly's Directory of Merchants, Manufacturers, and Shippers of the World, 1938. London: Kelly's Directories, Ltd., 186, Strand, W.C.2. Price 64s. net.

SIXTY YEARS AGO.

THE opening sentence of an article on "Water-tight Bulkheads" in our issue of June 14th, 1878, cannot be accepted as strictly accurate. So long as ships were built of wood, the author of the article wrote, it was practically impossible to fit them with water-tight bulkheads. Actually, Marco Polo in his travels during the thirteenth century noted and described the common practice of fitting such bulkheads in the wooden ships built by the natives of India. This slight criticism being set aside, the article was sound in all respects. Indeed, it sought to emphasise certain hard facts which were not driven fully home until after the disaster to the "Titanic" in 1912. Its author argued that the customary six or seven water-tight bulkheads with which ships were then fitted were, with the exception of the extreme forward, or collision, bulkhead, of little, if any, real use. If a ship rammed another, her collision bulkhead would probably save her from sinking, but, as in the recent case of the "Grosser Kurfürst," the ship which was rammed would, bulkheads or no bulkheads, almost certainly go to the bottom. The reasons for the inefficiency of the ordinary bulkheads were, the author stated, their general weakness, and particularly the weakness of their attachment to the hull structure—a weakness which frequently caused them to give way under the pressure of the water in the holed compartment—the difficulty of closing the water-tight doors quickly or of closing them at all if the bulkheads were twisted, and the fact that if the collision took place on the line of a bulkhead two compartments would be flooded, whereas the ship was designed to float with not more than one compartment open to the sea. It was impossible to reproduce in ordinary ships the extreme degree of subdivision adopted in our latest battleship, the "Inflexible," which was divided by transverse and longitudinal bulkheads into 135 compartments. Nor was it altogether practicable in a merchantman to follow the common practice exemplified in men-of-war of building the ship with a double skin, the intervening space between the skins being subdivided by bulkheads at short distances apart and the interior of the ship being subdivided by the usual six or seven bulkheads. As a compromise, the author suggested that the bulkheads at the point of attachment to the hull should be double and spread out like the limbs of a Y. Such a form of attachment, it was claimed, would not only assist the bulkhead to withstand the pressure of the water in the flooded compartment, but would also give the ship a sporting chance of surviving if she were struck on the line of a bulkhead, the argument being that if one limb of the Y were torn away from the hull, the other might well remain attached. As for water-tight doors, the author condemned as useless the common hand-screw arrangement employed to close them. He referred to the frequent suggestions and the numerous patents for the employment of hydraulic power for closing the doors, but he questioned whether it was possible to make a door which would be quite water-tight, would close in an instant, would not jam if the bulkhead twisted, would resist pressure from either side, and would not take up too much room. Until such a door was in general use water-tight bulkheads, however perfect they might be in other respects, were, he concluded, sure to prove useless in a moment of extreme emergency.

CONSTRUCTION OF SPILLWAY GATES AT PICKWICK LANDING DAM





Spillway Gates at Pickwick Landing Dam.

Interesting engineering details are found in the design, fabrication, and assembly of the steel spillway gates now being installed in the Pickwick landing dam on the Tennessee River. This dam is one of the largest spillway units of the T.V.A. project, which was described in The Engineer on April 15th, 1938. It contains twenty-two spillway openings, but requires twenty-three gates in order to provide a spare assembly. All were fabricated by Dravo Corporation, Pittsburg, Pa.

Each gate is composed of separate top and bottom sections, having the vertical side girders equipped with double-flange rolled steel wheels mounted on overhung axles. These wheels, 30in. in diameter, run on the gate tracks in the gate slots. The bottom sections are subjected to the greater pressures, and are therefore larger and heavier, each weighing about 65 tons. They are 41ft. wide and 20ft. 5⅞in. high, and have six roller bearing wheels on each side. Heavy fabricated silicon steel girders and diaphragms compose the framework to which is welded a ¼in. steel skin plate. It is said that they are the first spillway gates to have welded skin plates. All other construction is riveted. The top sections measure 41ft. by 20ft., but weigh only 40 tons. These parts are equipped with three bronze bushed wheels on each side. Steelwork consists of 36ft., 160 lb. wide flange rolled beams, with supporting diaphragms.

Because of the severe loads imposed upon the wheel assemblies of both sections, both the roller bearing and bushed units were designed to withstand high pressures. Representative roller bearing and wheel assemblies were tested at the Pittsburg testing laboratories for a direct radial load of 160,000 lb. applied at the wheel tread, and a thrust load of 60,000 lb., acting simultaneously with the radial load. Stationary and 1½ r.p.m. revolving tests were made. The bronze bushed assemblies received similar tests, and were found to be capable of sustaining a direct radial load of 130,000 lb. and a thrust load of 45,000 lb.

Each gate section is equipped with two cast steel lifting hooks tested for a tension load of 125,000 lb. These hooks are used in connection with a gantry crane operating on the spillway deck. In operation, when it is desired to raise the bottom section of a gate the top section is removed from the gate slot by the gantry crane, after which the bottom section can be reached by special gate-lifting extensions and raised to the desired position.

In all, forty-five sections have been delivered to the site by barge, as shown by an accompanying engraving, and are now being installed. One upper spillway section is designed to accommodate a special trash gate, specified as part of the contract.

South African Engineering Notes.

(By our South African Correspondent.)

Cape Town, May 24th, 1938.

Cape Town New Harbour Works Inaugurated.

The Prime Minister of the Union of South Africa, General Hertzog, on Tuesday night, May 10th, inaugurated the work of constructing important extensions and additions to the New Basin at Cape Town docks by setting in motion the machinery of a dredger in the basin area. Simultaneously he switched on a thousand electric lights outlining the new harbour area.. The new scheme, described in our issue of October 15th, 1937, which includes the reclamation of the foreshore, will cost £6,000,000 and take about four years to complete, and, in addition, a huge graving dock is to be provided at a cost of about £1,000,000, so that, with £4,000,000 already spent upon the New Basin by the Harbour Administration, a grand total of £11,000,000 will have been spent in providing it.

The Dutch contractors for the harbour scheme really started dredging on April 27th. Since the arrival in Table Bay recently of the first lot of working craft, their engineers and workmen have been busy daily fitting up the dredgers and preparing barges and lighters, pile drivers, and tugs for the strenuous work ahead. Up to the present five "tows" have been brought to Cape Town by the contractors' tugs. The sixth and last tow to come to Cape Town from Holland for the contractors should arrive early in June, about the same time as the self-propelling dredger "H.A.M. 2" should arrive under her own power. All the craft should therefore be in commission by the last week in June. The old fishing harbour is being used as temporary quarters by both the Dutch and Danish contractors, who are, between them, responsible for the new mole which will form the southern part of the New Basin entrance and extend to Woodstock beach at the head of the bay. It may be mentioned that the new Union-Castle mail ship arrived at Cape Town on her maiden trip on the morning of May 13th. The "City of Cape Town" is about 27,000 tons and can maintain a speed of 20 knots at sea with ease, being credited with having reserve power sufficient to drive her at nearly 24 knots an hour. A description of the vessel has appeared in The Engineer just recently, so it is not necessary to describe her here.

Bigger Waves in New Basin.

The fear that in the new basin big waves will adversely affect shipping was expressed by Mr. George Stewart, senior lecturer in the Civil Engineering Department of the University of Cape Town, in a lecture recently. The height of a sea wave, he explained, depends largely on the length of open sea over which the wind travels, which is called the "fetch." In the new basin that is being constructed there is an open stretch of 6000ft., over which a south-easterly gale would travel, and this "fetch" will undoubtedly cause much greater waves at the South Arm than at present, though even to-day, when the "fetch" is only 2500ft., difficulty is experienced in carrying out shipping work, particularly undocking. Referring to previous schemes for the construction of a harbour at Cape Town, the lecturer pointed out that the present scheme was similar to that proposed by Messrs. Methven and Hammersley-Heenan in 1902, who, however, limited their "fetch" to 3000ft. In 1923 a similar scheme was proposed with two others, but was objected to on account of the supposed difficulty of removing rock under water. Mr. Stewart, however, then appeared before the Commission and gave facts and figures showing that the cost of subaqueous rock removal need not be prohibitive. The length of 6000ft. for the new basin was fixed. Mr. Stewart believes in the idea of giving accommodation for flying boats, but a stretch of water free from shipping and *débris*, such as Zeekoe Vlei or Saldanha Bay, he considers more suitable.

"Iscor" Progressing Well.

The "Iscor" steel works of the South African Iron and Steel Industrial Corporation, situated at Pretoria, is making rapid progress. During the week ended May 14th it produced its millionth ton of steel after a working

life of approximately four years. It took two and a-half years to produce the first half million tons of steel, but the all-round increase in efficiency, the addition of a second blast-furnace, and improvements introduced, made it possible to produce the second half million tons in eighteen months. Although the heavy mills were designed to give an output of 200,000 tons a year, they produced 263,360 tons last year. The coking ovens designed to give an output of 500 tons are producing 545 tons a day. The steel shop has shown a record production of 33,491 tons a month, with a daily record of 1615 tons. The heavy mill, which produces rails, channels, angles, and rounds, and sends semi-finished materials to the sheet mills and light mills, had a daily record of 1169 tons. Last year the light mills turned out 49,225 tons of material, including 3000 miles of half-inch round wire and 8500 miles of five-sixteenths inch round wire. The sheet mills were designed to produce 700 tons of material and are regularly exceeding this by substantial quantities.

All the raw materials are within easy reach of the works. Of the iron ore charged into the blast-furnaces, 82 per cent. comes from Thaba Zimbi, 155 miles from Pretoria. This ore averages 66 per cent. metallic iron, which is about the highest known. The remaining 18 per cent. comes from an open quarry in the Pretoria series of the Transvaal system and approximately one mile from Iscor. Because of the high percentage of metal in the Thaba Zimbi ore it is necessary to introduce silica to produce the necessary physical conditions of slag. This slag is obtained from the Pretoria town lands. Dolomite, another necessity, is obtained near the site of the furnaces, and limestone, lime, and manganese are all obtained within a short distance of the works. The iron ore deposits and the others mentioned all belong to the Corporation. Fluorspar, fire-clay, and silica bricks are obtained from Warmbaths and Vereeniging, while chemicals such as hydrochloric acid are made at Modderfontein. Coal for the coking ovens is obtained from Witbank and Natal. To-day Iscor employs approximately 3250 Europeans and pays a monthly wage bill of approximately £60,000; during the four years of its existence it has paid nearly £25,000,000 in wages. Ninety per cent. of the raw materials used are of South African origin.

At present the Iscor Corporation is considering the possibility of enlarging its steel-making activities, but before anything is done the Corporation will make the same careful investigations into the economics of such extensions as those that preceded the establishment of Iscor.

It may be mentioned that the site for a large blast-furnace has been purchased at Meyerton by certain interests, and a company is to be floated to exploit the iron ore deposits in the district. An English expert has been engaged to prepare the details. Pig iron will be produced and possibly steel suitable for the manufacture of tubes.

Making Guns in the Union.

Steady progress is being made with the proposed manufacture of war material in the Union. A 4½in. howitzer barrel has just been completed by the firm of Wright, Boag and Co., Ltd., of Johannesburg, who produced a trench mortar in December. The barrel, which was made to War Office specifications, has been delivered to the Department of Defence for testing. In addition to the first South African-made trench mortar, successfully tested at Quaggapoort in December, the War Supplies Board has had bombs, hand grenades, and other essential war materials manufactured in the country, while the aircraft and artillery depôt at Roberts Heights is turning out two Hawker-Hartebeest aircraft a week to supplement the Union's growing Air Force. The aircraft depôt has also successfully produced smoke bombs. The object of the War Supplies Board is to investigate the Union's defence resources. A great deal of experimental work was necessary before the howitzer barrel, which weighs 385 lb., could be completed. A special machine had to be built for the rifling. Imported high-grade steel had to be used because its equivalent is not produced in South Africa yet. To cut the rifling alone took about 200 hours, and the rest of the work a week. Now that the machine has been set up it can produce numbers of barrels if necessary. Wright, Boag and Co., Ltd., have also produced six 3in. mortar barrels for use by Defence Force units. The 4½in. howitzer is claimed to be the first modern field gun manufactured south of the line, but it is not the first gun manufactured in the Union. The siege of Kimberley led the De Beers Company to start work on December 26th, 1899, on the manufacture of the famous "Long Cecil," to prove a gun of greater range and efficiency than any at the command of the garrison. The gun, which is now mounted at the memorial, was designed by George Labram, chief engineer, De Beers' workshop. It has a calibre of 4·1in. and is 8ft. 2¾in. long.

New Power Station for Port Elizabeth.

Port Elizabeth is awaiting the report of the Electricity Supply Commission on the scheme for the big new electricity undertaking for the city, submitted by the British expert, Mr. Ryder, towards the end of last year. At present, as regards the generating plant, the municipality has retained as stand-bys two 1000-kW and three 3000-kW sets. During the past few years two 12,500-kW turbine sets have been installed. The present boiler installation consists of eight Babcock and Wilcox marine type boilers varying in capacity. Four of the older type boilers have been retained with a total evaporative capacity of 88,000 lb. per hour, together with four other boilers installed at a later date and having a capacity ranging from 50,000 lb. to 70,000 lb. per hour. The new power station will cost between one and two million pounds and is vital for the future of the city, as any further extension of the existing station is virtually impossible. In the meantime it has been necessary for the Council to vote a further £1,000,000 for new plant to tide the department over till the new station has been built. During 1937 there was a very substantial increase in the number of units sold, which exceeded 50,000,000. In the year 1935 the number of units sold was 36,000,000. The rate of expansion continues to increase.

National Roads Under Way.

The National Roads Board is now well under way in its task of constructing 5400 miles of good roads in the next four or five years, at a cost of about £18,000,000. The Board has already borrowed part of the planned amount from the Government Treasury, and anticipates a total expenditure for 1938–39 of between £3,000,000 and £3,500,000. Its plans include the construction of magnificent 5-mile to 10-mile approaches to all the principal cities of the Union. The establishment of 250ft. road reserves, which will provide for ample expansion for generations to come, is aimed at. Such approaches will be on the double-road principle, ensuring one-way traffic. The approach to Cape Town will be one of the most important in the Union. It will be built on the reclaimed land of Table Bay. The Board intends building three national roads into Cape Town, one from the north, one from the south coast, and one from the direction of Malmesbury. With a view to construction of one of the finest tourist drives in the world, the Board will visit the Natal South Coast towards the end of June. A national road is to be built along the coast to Port Shepstone. If a road on the coast line is not practicable the road will run inland for certain distances. The Board is consulting the four Provincial Townships Boards before drafting legislation to control "ribbon" development along the main roads.

Railway Transport and Electric Traction.

The railway transport crisis through which the Union has recently been passing and which has not yet entirely disappeared has more than proved the superiority of electricity over steam for railway haulage. The Railway Administration's greatest difficulty was not so much the shortage of trucks, but its inability to use truckage to greater advantage owing to the long distances to be traversed, accentuated by the transport of goods being mostly over a single line track. As a result coal trains from Natal collieries to the Cape often take a week to travel to Cape Town and the round trip lasts from ten to fourteen days. A large proportion of this time can be regarded as wastage, as frequently no goods are carried on the return trip. As a comparison of the haulage conditions under steam and electricity it is interesting to consider that prior to 1924, when electric traction had not yet been established, the average haul under steam was about 800 tons, and not only had the load to be broken up in negotiating certain sections, with several changes of engines, but the state of congestion on the track frequently resulted in as many as five freight trains being held up in one station awaiting a clear section. Another factor was the slow speed of steam trains on the very heavy gradients. The journey to the coast and return took twice as long as to-day. With the present system of electric working no difficulty is experienced in hauling 2000 tons from Glencoe to Durban with four electric units in ten hours, and, allowing a day for offloading, the return trip to the collieries could be accomplished in forty-four hours, involving a saving of over a day against the performance under steam conditions, apart from the fact that much larger hauls are made by electric units and that the same units can be used for the entire round trip and be ready for service again immediately. Haulage on the Cape route has been materially assisted by the electrification of the main line to Harrismith, which has cut down the original steam times by a substantial margin. It is reported that the railway authorities are carrying out investigations involving the electrification of the main line to Bethlehem. As far as the Cape is concerned it seems worthy of consideration to investigate electrification of a section of the main line from Cape Town to Touws River, as unlimited power is likely to be available from the Cape Town power systems in the near future. On the Transvaal system north of Volksrust scope also exists for investigating the extension of the electrified railway system to the Rand, as it is obvious that with the facilities for a fast trip over a completely electrified track between Durban and Johannesburg a considerable amount of time will be cut off the round trip for goods traffic. While the ideal form of transport over the main lines of this country with long distances to be traversed, and the necessity for quick return of truckage, would be electric traction, with its greater flexibility and speed, it is obvious that at present it is economically impossible.

Unmapped Coalfields.

The belief that about 7000 square miles of South Africa is underlaid by coalfields, but that of this area only 3000 square miles have been mapped was expressed by Dr. P. E. Hall, of the Fuel Research Institute, at the meeting of the Institution of Certified Engineers in Johannesburg, recently. The objects of the Institution, he said, were to grade coals, to investigate the fuel resources of the Union, to undertake research on solid, liquid, and gaseous fuels, and to investigate any matter referred to it by the Government. The Union has vast supplies of coal. Omitting enormous quantities of low-grade coal, the estimated quantity is 226,771,434,000 tons of good calorific value, but it has no reserve of liquid fuel. At the Institute coals are graded according to their calorific value. Samples are taken frequently to see that the grades are being maintained, and for this purpose an adaptation of the rotary coal drill has been devised, a portable machine, by means of which representative samples can be taken directly from the line of coal trucks. No liquid or gaseous fuel resources having so far been found in the Union, the survey of the Institute has been mainly on solid fuels, coal, torbanite, and lignite. Tests on the hydrogenation of Natal coal have been negative, but coal from Vereeniging, Ermelo, and Witbank is suitable. Work has shown that tests which apply to coal produced overseas often fail in the Union.

Pulp and Paper Industry.

The South African Pulp and Paper Industries, Ltd., a promotion of the Union Corporation, Johannesburg, hopes that everything will be ready by the end of the year for a trial run of the new factory to be erected on a site on the farm Geduld, on the East Rand, where adequate water and transport facilities are available. Arrangements are being concluded for the supply of all the necessary raw materials, of which considerable quantities have already been delivered. Nearly all the raw materials, with the exception of pigments and resin, will be entirely of South African origin, and there is a probability that resin may also be available in South Africa shortly. The factory is to consist of three sections—the chemical section, the pulp section, and the paper and cardboard-making section proper. The company states that it will not be necessary for the industry to ask for protection, but it has already been in touch with the Board of Trade regarding the possible contingency of dumping.

Lack of Engineers.

The various branches of engineering are experiencing an acute shortage of trained men, and, despite the fact that engineering faculties of the universities of the Witwatersrand and Cape Town have a record number of registrations, it seems that the importation of trained personnel is the only immediate remedy. The mines, municipalities, private firms, as well as the Provincial Administrations, are all suffering as a result of the depression years, when new entrants into the professions were conspicuous by their absence. The dearth of trained men has been accentuated by the fact that in the past salaries offered for fully qualified civil or electrical engineers have been totally inadequate, mostly of the order of £20 or £25 per month. A month or so ago the Transvaal Provincial Roads Engineer, in his annual report, made the following statement:—"It has become well nigh impossible to obtain experienced engineers for road work. Unless importations from other countries are resorted to the shortage will be acute for many years to come. It is, however, not likely that good men will be obtained from overseas at the salaries which we can offer in terms of new scales laid down by the Public Service Commission." The powers that be are now cognisant of these facts. Some municipalities have recently increased their salary scales and there will have to be a pretty general scaling up or Government Provincial Councils and Municipalities will find the migration of their engineers to private mines and manufacturing works assuming serious proportions—a number have already gone. Particular difficulty is being experienced in the mining industry, in the carrying on of the national roads programme, which calls for 5400 miles of tar-surfaced main roads, at a cost of £18,000,000, and within the next five years or so, in the carrying out of sewerage and water schemes, but there is also difficulty in finding competent men in a number of other directions, such as the many new industrial enterprises being embarked upon, and so on. So far there is little sign that the opportunities for steady positions at good salaries—a minimum of £35 per month, may now be assumed in any of the avenues of employment referred to—have had any attractions for British engineers, but it is otherwise on the Continent. In Holland, whence a couple of hundred of skilled building employees came at the height of the shortage of skilled men in the building trade last year, the possibility of an emigration of Dutch engineers is being investigated, especially for the purpose of road construction. Dr. Idenburg, Secretary of the Leyden University, is dealing with the matter. There are difficulties in the way, because a Dutch engineer's certificate is only accepted in South Africa after a supplementary examination.

Metal Cutting Band Saws.

In the accompanying engravings we illustrate two machines which form part of a new range of metal cutting band saws and cutting-off machines manufactured by the Midland Saw and Tool Company, Ltd., of "Midsaw" Works, Pope-street, Birmingham. The sole export agents for the company, as well as its agents for Southern England, are Messrs. Morrison, Marshall and Hill, of Coventry House, South-place, London, E.C.2. In Figs. 1

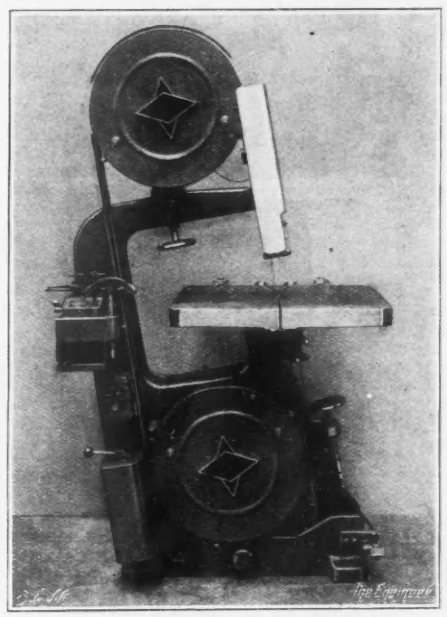


FIG. 1—TOOLROOM BAND SAW

and 2 is shown a toolroom band saw which can be used in the manufacture of dies, press tools, templates, gauges, and other similar work of regular or irregular form. The machine forms one of a range of band saws which are claimed to be the only British-made machines of their type and by continuous and rapid cutting they are stated to save considerably in manufacturing costs as compared with older operations of drilling, slotting, milling, and filing.

The machine illustrated is suitable for cutting steel and

other materials up to about 9½in. in thickness and is fitted with a canting body. The machine can also be obtained with a rigid body, but the canting body pattern is recommended for use when sawing heavy dies at an angle, for by canting the body the work remains in a horizontal position, thus avoiding the tendency of the work to slide to one side and causing damage to the saw, or an inaccurate cut. The body is arranged to cant in two directions from the vertical up to 15 deg. each way. This swivelling adjustment is made by a hand wheel operating a screw spindle with right and left-hand threads.

Of robust construction, the table on the machine illus-

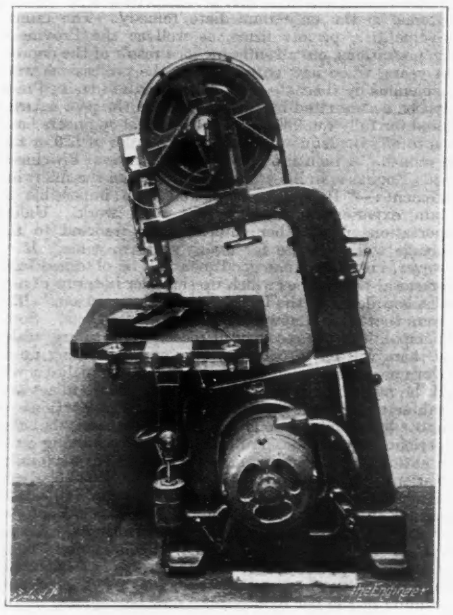


FIG. 2—TOOLROOM BAND SAW

trated is 30in. square, accurately machined and arranged to tilt in four directions up to a maximum of 15 deg. Spirit level gauges and a graduated scale are provided for indicating the angle of tilt. So that the table can be readily set in the horizontal position after having been tilted, a positive locking device is arranged; the table can be clamped in any intermediate position.

The saw wheels are fitted with parallel saw tracks and are balanced and carefully mounted. In order to prevent damage to the saw teeth and to eliminate any tendency for the blade to slip the wheels are provided with vulcanised rubber treads. A special device is fitted whereby the saw can be tracked while the machine is running. Saw tension is maintained by a compression spring and it will be noted from the engraving that the saw wheels are of large diameter—actually 22in. diameter—a feature which helps to give a long life to the saw. Two guides are fitted, one

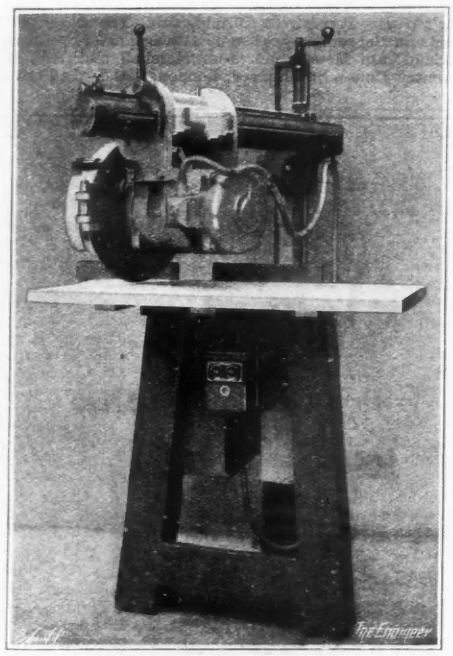


FIG. 3—CUTTING-OFF MACHINE

above and one below the table, the top guide being adjustable for height. Each guide has two points of support for the saw, 5in. apart, and the guides are so arranged that without alteration to the fittings they can support any width of saw up to the bottom of its gullets. The thrust portion of the guide is provided with ball bearings both for the thrust and the radial motion.

An air pump is fitted which is stated to cool the saw blade and at the same time blow away the swarf. Special attention has been paid to the arrangement of the guards, with the result that efficient protection is afforded and yet the saw blade is readily accessible for changing.

The machine is motor driven through an oil-filled gear-box, the drive being taken directly from the gear-box output shaft to the lower saw wheel. Approximately 1 H.P. is required for driving the machine. Although the machine can be supplied with only one speed—140ft. per minute—four or eight-speed machines are recommended when varying types of steel or other materials are to be cut. The four-speed machine has saw speeds of 80ft., 120ft., 160ft., and 240ft. per minute, while the eight-speed machine gives a range from 40ft. to 480ft. per minute. With a multi-speed machine a four-speed motor is fitted, which is controlled by a single lever and the eight speeds are obtained by means of a two-speed gear-box. The drive is direct and positive, as there are no belts and no clutch; it is claimed that speed changes can be quickly made.

An automatic gravity feed device, which exerts a constant feed pressure and enables the operator to concentrate on guiding the work, can be fitted, if required. This device is provided with a foot control, which stops the feed without the necessity of the operator taking his hands from the work.

A brazing attachment, worked by means of an electrical transformer, can be fitted for the purpose of joining the ends of the saw blade after threading it through the work. The attachment operates on single-phase A.C. lighting supply and is placed on the machine in such a way that it can be adjusted in a horizontal plane away from or towards the frame of the machine. It can also be swivelled in the vertical plane, so that whatever may be the position of the saw in relation to the work, the attachment can be adjusted to suit.

The following table gives the cutting times for the machine as quoted by the makers:—

Cutting Times Per Inch Length of Cut.

Material.	Mild steel.	Carbon steel.	Nickel-chrome steel.
Tensile strength, tons per square inch ...	30	45	65
Thickness, inches	Min. sec.	Min. sec.	Min. sec.
¾	0 20	0 30	0 50
1	0 35	0 50	1 10
1½	0 50	1 15	2 50
2	1 45	2 0	3 35
3	2 0	2 45	5 45
4	3 20	3 45	7 0

In addition to the range of machines described above, the firm manufactures many new types of metal cutting band saws for non-ferrous metals, bakelite, &c. These machines are for the most part specially designed to suit the materials to be cut.

Another interesting new machine is the cut-off machine, illustrated in Fig. 3, which is suitable for cutting off extruded non-ferrous sections. The machine is claimed to be better adapted than a band saw for this class of work, and it can also be used for other purposes, such as the cutting of regular light section die castings and plastic materials.

The body is a solid box casting of T-section, in which is mounted a rotatable vertical post, which can be set to any desired angle and securely locked thereat. By means of a screw adjustment the horizontal arm can be moved vertically on the post, a ball thrust bearing and washer being fitted. For the sake of rigidity the arm is cast in one piece with the vertical sleeve. Made from aluminium, the sliding carriage is mounted on steel bearing rollers which run on carbon steel rods. The steel rollers are provided with an adjustment to take up wear and they are totally enclosed, so that dirt cannot interfere with the free movement of the carriage. A hand-operated movement for the carriage, with adjustable stops and a gravity return device, is fitted.

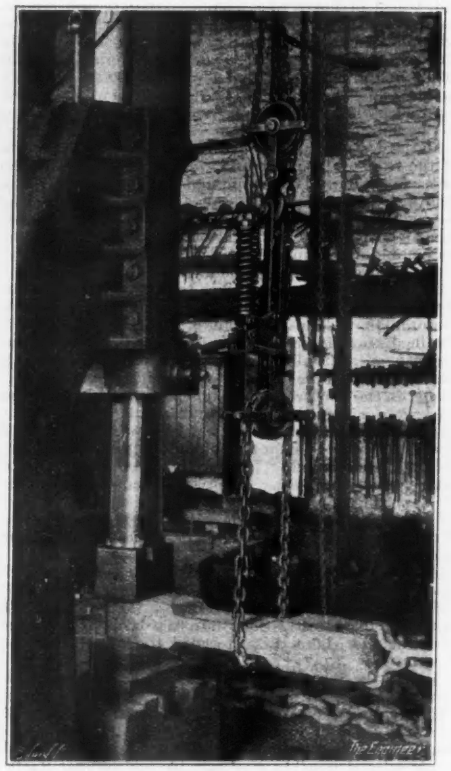
Totally enclosed, the driving motor is adjustable around the spigoted ends of the carriage through 90 deg. for bevel cutting, hence the carriage always remains in a horizontal position and the weight on the supporting rollers is approximately constant. The saw is mounted on the motor shaft in line with the vertical post. The maximum diameter of the saw is 14in. and the length of saw traverse is 20in., while the maximum depth of material that can be cut is 3in. The saw runs at 2800 r.p.m. and requires a 2 H.P. driving motor.

The machine is normally supplied with an oak table—although cast iron can be specified. Two cast iron adjustable fences are fitted at the back of the table and the arrangement is such that the work can be supported near the saw at whatever position the saw is in.

Spring Shock Absorber.

THE stress in a chain or rope subject to shock or jerking can be divided into two components: firstly, the static stress, by reason of the load; and secondly, the kinetic stress caused by the shock. In the case of moving loads an additional stress caused by the inertia of the load, composed of the force required for acceleration, of course, also exists. The Safety in Mines Research Board paper No. 78 notes that the shock stress, in connection with colliery winding ropes, reaches a figure of 2·47 times the dead load, and it is quite probable that under less exact conditions this multiple might reach a figure of three times the dead load. The prevention or material diminution of shock stresses is therefore of considerable importance to the life of the material under stress and also at times to general safety.

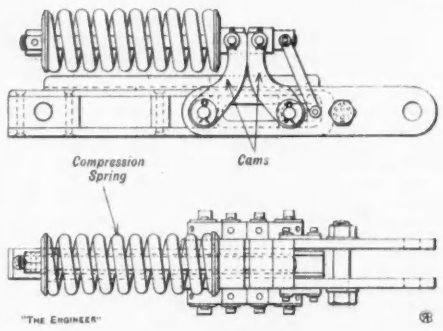
The accompanying half-tone engraving shows a "Monarch" patented shock-absorbing device used for supporting the work for a 7½-cwt. pneumatic hammer in the repair shops of the Tees Conservancy Commission. In addition to hammer work, these units, manufactured by the Monarch Controller Company, Ltd., of 7, Victoria-street, London, S.W.1, can be applied to colliery cage hoists, tugs, ships' moorings, and so forth. The principle of operation is shown in the drawing reproduced herewith, in which it can be seen that the shock-absorbing unit consists of a lever linkage with a compression spring interposed, which is inserted in the rope or chain. The extension of the unit causes the fulcrum of the leverage system to move as the cams turn, thus giving a variable effective strength to the spring—the greater the load, the stiffer the effect of the spring. For this reason it is claimed that the one unit is applicable to a wider range of load than would be possible using a plain spring in tension or compression. The shape of the cams is such that the load-travel curve is a parabola, instead of the straight-line characteristic of a directly loaded spring. Furthermore,



SHOCK ABSORBER ON PNEUMATIC HAMMER

a directly loaded spring is only suitable for a particular load, whereas the "Monarch" device is claimed automatically to adjust itself to all loads within the limits of the design.

Power hammer work is a case in which the shock can reach a damaging value if the work is not supported truly with respect to the level of the anvil. Therefore, with varying sizes of work the use of a directly loaded extension spring shock absorber would require a number of



ARRANGEMENT OF SPRING SHOCK ABSORBER

different springs to suit the varying weights and shapes of the work. The wide range of the "Monarch" device is claimed to be of particular value in such a case.

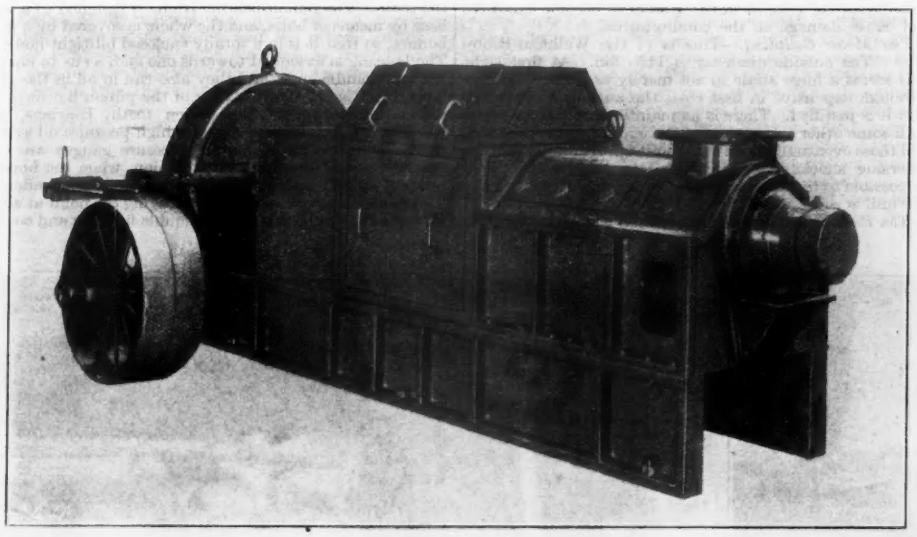
Vegetable Oil Mill Machinery.

FOR the first pressing of seeds and nuts which are rich in oil, such as copra, ground nut kernels, palm kernels, rape seed, and so forth, economies are claimed by Rose, Downs and Thompson, Ltd., Old Foundry, Hull, for the use of an oil expelling machine as opposed to the older and more cumbersome forms of machinery hitherto used for this purpose. The machine made by the firm is known as the "L.C." oil expeller and is illustrated in the accompanying engraving.

When provided with kettles of the necessary cooking capacity, the expeller is said to be capable of first pressing up to 60 tons of ripe copra per day of twenty-four hours and extracting up to 75 per cent. of the oil contained therein. Smaller quantities—from 20 tons and upwards per day—can also be first pressed with economy by installing the machine to take the place of a number of smaller expellers, with an arrangement of small kettle units to suit the capacity required. The method has the further advantage that kettles can be added to the machine to increase the output without alteration to the expeller or increasing the floor space occupied.

In order to secure alignment and stability the machine is supported on heavy beam castings, to which is secured the driving gear case. As shown in the illustration, the

drive is effected by fast and loose pulleys, but V-rope or enclosed chain drive from an electric motor can be readily arranged. Mounted on heavy ball and roller bearings, the main shaft drives through a single reduction worm gear,



VEGETABLE OIL EXPELLING MACHINE

which is totally enclosed and runs in oil. The driving worm is made from alloy steel, hardened and ground, and the worm wheel is fitted with a bronze rim. The pressure worm shaft runs in large bronze bearings, a ball thrust bearing being provided for taking the end thrust. It can be removed without disturbing the driving gear or the thrust race, as a splined drive is utilised, eliminating the use of loose keys at a point where the driving load is heaviest.

In operation, a feed worm passes the cooked seed into a tapered chamber where the seed is consolidated, then into a preliminary pressing cage which is drilled with small holes. The preliminary cage is made in halves and can be removed without disturbing the worms or the shaft. After being pressed in the preliminary pressing cage the seed is compressed into the main pressing cage, which is lined with specially shaped steel bars held in steel rings supported by heavy clamping bars and bolts. The oil escapes through spaces between the lining bars. In the preliminary and main pressing cages the pressure worms exert an extremely high pressure on the seed.

The cake outlet is formed by a fixed die, which is interchangeable with two other dies, each providing a different cake pressure and thickness of cake, to suit the seed being treated. Interchange of the dies is readily effected and, since there are no moving parts, the system provides a reliable cake pressure adjustment. Steel cutters on the worm shaft cut the cake into conveniently small pieces and drop it away from the cage.

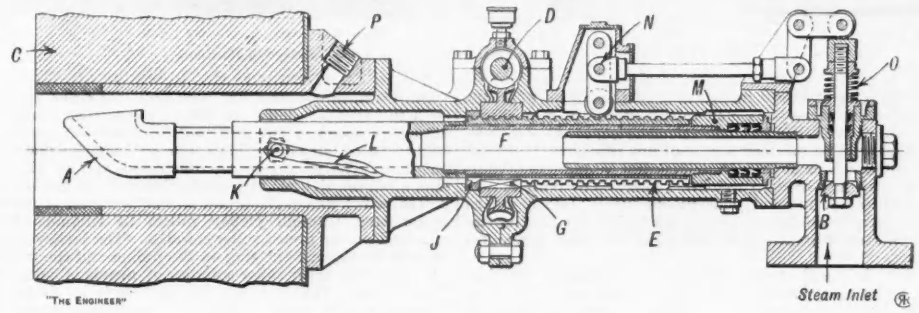
All parts subject to wear are stated to be made of alloy steel, carefully heat treated and hardened. Pressure grease lubrication is fitted as standard, although Stauffer lubricators can be provided if desired.

For driving purposes the power required for the machine varies with the material to be treated and the capacity at which the machine is being operated. When working at maximum capacity on palm kernels the power required, exclusive of the power for the kettles, is stated to be approximately 35 H.P., whilst at maximum capacity on copra and ground nut kernels a figure of 30 H.P. is mentioned.

For the final oil extraction from the cake which is produced by this oil expeller, high-pressure expellers, hydraulic presses, or solvent extraction plant can be used, all of which type of plant is being manufactured by the firm.

Soot Blowers.

THE accompanying drawing illustrates a single retractable nozzle soot blower made by Hopkinsons, Ltd., of Huddersfield, which is particularly recommended where high temperatures are experienced. It is so arranged that the steam valve is automatically synchronised with the movement of the blower head, and the glands are isolated by an automatic valve except when the blower is in actual operation. The device is so designed that it can easily be adapted for remote control. In the drawing the nozzle A is shown in its retracted position. By the simple turning of the worm D the nozzle is projected, the valve B opened as soon as the nozzle is clear of the wall C, and the nozzle rotated through the required angle. A screwed and splined sleeve E loosely surrounds the blower tube F. It is rotated by the key G, on the worm wheel, and is thus caused to screw in or out of the fixed nut J, projecting the blower tube outwards or inwards. Oscillation of the nozzle results from the working of the fixed pin K in a helical keyway in the blower tube. The steam valve is opened, when the nozzle is sufficiently projected, by the contact of a hardened steel gland box M with the roller on the trigger N. When the nozzle is retracted the valve closes as a result of the action of the steam pressure combined with the effect of a balance spring O. Where gas temperatures exceed 1800 deg. Fah. it is recommended that if there is negative pressure in the furnace air be induced through the boss P for cooling purposes, and if the pressure be positive that a pipe line of not less than 1in. bore should be connected to the boss and admit air from the forced draught duct. A similar multiple nozzle, but non-retractable, soot blower is also made.



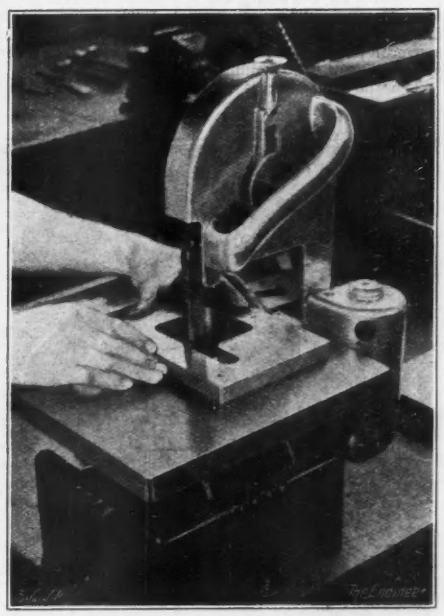
RETRACTABLE SOOT BLOWER

A New Filing Machine.

THE accompanying illustrations show an interesting continuous filing machine, which is now being made in this country by George H. Alexander Machinery, Ltd., 82–84, Coleshill-street, Birmingham, 4. Known as the "File-all" the machine consists of a light aluminium alloy frame holding a file band driven by an electric motor. The ¼ H.P. universal motor is fixed directly over the main frame of the machine in order that the weight may be balanced above the point of work. A tensioning device is incorporated in the idling pulley at the opposite end of the frame to the drive in order to take up any wear and to release the tension when changing files. A hook is provided to put over the edge of the work to assist the operator when using the machine for hand filing. The file band is built up of 2in. long segments riveted to a flexible steel band. On the working stroke the ends of the file segments interlock to form a rigid column, and this column is supported at the rear by a hardened, channel-shaped, back plate.

CONTINUOUS FILING MACHINE

The machine is easily converted for use as a bench machine by fixing it on end in the base and work table assembly shown in the illustration. This work table may be tilted at any angle, and the machine is adapted for internal as well as external filing. As the machine has an overall width of under 8in., internal filing of large diameters is carried out by inserting the complete unit.



FILING MACHINE MOUNTED ON WORK TABLE

AMERICAN GOLD-DREDGING PRACTICE.

DREDGING gold-bearing gravels has been practised so long and on such a large scale in California that methods have become almost standardised in a general way. But with the working out of many of the larger and richer deposits there are developments in the dredges or excavators and in the methods used for the recovery of gold. Most of the dredges are of the ladder type, with an endless chain of buckets operating on a boom or ladder frame. The largest of these machines can dig to depths of about 150ft. and can handle about 600 cubic yards of material per hour, while elevating and stacking the waste gravel and sand in a pile about 100ft. high above the water. The operating cost is about 2½d. per cubic yard. The material excavated is washed and screened, the size below ¾in. passing to tables having riffles and mercury traps. Jigs sometimes supplement the riffles to increase the recovery of gold, and in a few cases there is a grinding and polishing section in advance of the revolving screen or trommel. This latter process is a development of the earlier use of ball or pebble mills to break up cemented masses. Flotation has been tried experimentally, but encounters the difficulty of handling excessively large tonnages. A relatively new feature is the use of dragline dredges for deposits too small to warrant the construction of a ladder dredge. A hull about 28ft. by 24ft. has a 1¾ yard bucket operating at depths of 18ft. to 25ft., and excavating about 50 yards per hour. A 125 H.P. oil engine operates the bucket and a similar engine of 65 H.P. supplies power for the trommel and pumps. A disadvantage is that the action of the bucket keeps the pond in a state of turbulence with a back flow that carries much of the finer gold-bearing material away from the bucket. However, by the use of a pump, with suction inlet following the bottom of the bucket, much of this fine material may be collected and delivered to the treatment apparatus. A small amount of residuum thinned with kerosene forms an oily scum that may contain as much as 75 per cent. of the fine gold.

ZINC.—We have received from the Zinc Development Association, Great Westminster House, Horseferry-road, London, S.W.1, a copy of its first publication, "Zinc: Its Manufacture and Uses." This booklet, which is issued free of charge to persons interested in the material, gives a brief history of zinc, sources of supply, extraction, and properties. The various coating processes are described, together with particulars of the rolling and uses of rolled zinc, die castings, and zinc pigments.

A LARGE WINDING ROPE.—What is believed to be the largest winding rope in Europe has been made by the Whitecross Company, Ltd., of Warrington. Designed for use on the Koepe system of winding, the new rope is over 4400ft. in length and 8in. in circumference, having an actual breaking load of 327 tons and weighing 22 tons. Constructed on the "Contra-Lock" self-tightening principle, the rope is made up of eleven round outer strands over two layers of flat strands on a concentric core, this having proved in service the most suitable construction to resist wear and slip on the Koepe pulley.

The Design and Operation of a Modern Blooming Mill.*

By W. F. CARTWRIGHT.†

(*Continued from page 632.*)

THE control of the mill motor itself is on the Ward-Leonard principle, and for this purpose a separate exciter set is employed, consisting of a 73 H.P., 3300-volt synchronous motor which drives three exciters, one for the generators, another for the main mill motor, and a "bucking" exciter for weakening the mill motor field for speeds above 62 r.p.m. This set runs at 1000 r.p.m., and by suitable adjustment of the synchronous motor excitation the overall power factor of the complete Ilgner equipment is maintained at 0·95 lagging.

When the controller is moved from the "off" position the field of the generator exciter builds up, thus in turn building up the fields of the three generators. The mill motor, with full field applied from its own exciter, begins to rotate, until it reaches its base speed of 62 r.p.m. with full generator voltage applied to its armature. Further movement of the controller keeps the applied voltage constant and cuts resistance out of the field of the bucking exciter, the armature of which is connected in series with, and in opposition to, the main exciter. The polarity of the bucking exciter is so arranged that a strengthening of its field reduces the field strength of the mill motor, and the mill motor therefore accelerates up to a maximum speed of 150 r.p.m. when the controller has completed its travel.

These remarks apply to either direction of rotation, the polarity of the mill motor field being retained while that of the applied voltage is reversed.

If the controller is now moved towards the "off" position, the field strength of the mill motor is increased, causing it to regenerate power, which is returned to the Ilgner set, and this brings about a rapid deceleration to the base speed. Further movement of the controller weakens the generator fields, and the mill motor is brought to rest, first by further regeneration, which persists so long as the back E.M.F. of the motor is higher than the generator voltage, ; second, by dynamic braking in the "off" position when current is circulated through the unexcited generators ; and third, by plugging when the generator voltage is reversed.

Should the controller be moved abnormally fast it is possible for the current in the system to become excessive and cause damage to the commutators.

The Motor Coupling.—This is of the Wellman-Bibby type. The outside diameter is 11ft. 6in. At first sight this seems a huge affair to act merely as a coupling, but although expensive in first cost, the author is convinced that it is justified. There is no maintenance cost, whereas with some other types wear of the sliding surfaces occurs, and these eventually have to be built up with welding. No reversing shocks are transmitted to the motor ; it is impossible to feel even a tremor on the motor casing when the mill is reversed.

The Pinions.—These are of unusual construction. The usual type of pinion housing in this country consists of a U-shaped casting into which the bearings and pinions are dropped, a cap then being bolted across the top. When under load the stresses set up by the pinions tend to split this "U" open, which has, in fact, happened on many older mills, as there is no tie in between the two pinions. The split in the bearings is on a horizontal line where the bearing pressure is nearly at a maximum, which makes the provision of forced-feed bearing lubrication very difficult. The oil sprays for the teeth are usually so inaccessible that there is a danger of their becoming neglected. The pinions are not really rigidly located, relative to each other, due to the sliding fit required in the "U" of the housings and the vertical pressure required from the cap to keep them from climbing on each other. Finally, the pinions in many mills are of carbon steel of about 38–44 tons per square inch tensile strength, requiring a coarse pitch to withstand the stresses imposed. All these factors tend to produce a gear of low efficiency. In fact, the pinions in most English mills would compare unfavourably with any modern reduction gear. The pinions now described are, however, constructed exactly like a modern high-speed reduction gear, except that the two axes are in the same vertical plane instead of the same horizontal plane.

The pinions themselves are of silico-manganese steel of about 50 tons per square inch tensile strength, with an elastic limit of over 28½ tons per square inch. This steel is highly resistant to wear, and at the same time its toughness enables a very fine pitch to be used. The pinions lie in cast steel shells lined with white metal, which rest in a vertically divided cast steel frame. The two halves of the cast steel frame are rigidly connected to each other by means of very large bolts of a high-tensile steel, so that the frame itself is relieved of the stresses arising from the teeth. The pinion-bearing frame is fastened to a wide base by means of bolts, and the whole is covered by a plate bonnet, so that it is in a totally enclosed oil-tight housing. The housing is extended towards one end, so as to enclose the two spindle ends, and they also run in oil in the same housing ; Fig. 11 shows a view of the pinion housing.

The lubrication of the pinion teeth, bearings, and spindles is effected by means of a high-pressure oil system driven by an electric pump. Pressure gauges are connected to each pipe line. In addition, when the housing cover is lifted, each jet can be inspected independently. The teeth are lubricated by jets spraying the point at which they mesh from both sides. A double filtering and cooling system is employed, so that either can be cleaned out and examined while the other is running. For starting, an additional electric oil pump is provided, the motor of which is connected in such a way that the mill cannot turn until the starting oil pump has fed a sufficient quantity of oil to all parts.

Breast Rollers and Drive.—The breast rollers themselves are of excellent design. They are of solid forged steel running in white-metal bearings. There is a spring under each bearing to take any shocks. These springs broke repeatedly at first, but after fitting a better quality, this trouble disappeared. Up to date, no breast roller has broken

Nearly every blooming mill suffers from time to time from some form of breast roller trouble. At Cardiff such trouble as has occurred has been with the drive and not with the breast rollers. The drive has never caused any actual stoppage in the mill, but has probably caused a slight loss of output at times, due to being insufficiently positive. The arrangement, illustrated in Fig. 12, consists of a smooth steel ring on the front end of the bottom pinion, which drives the breast rollers by means of friction transmitted through jockey rollers to friction wheels mounted on the breast roller spindles. The jockey rollers are pressed against the ring on the pinion and the friction wheel on the breast roller spindles by means of solenoids. The current is switched on to the solenoids by the motor driver during the first six or seven passes only, thereafter the breast rollers run free. Only the solenoid on the

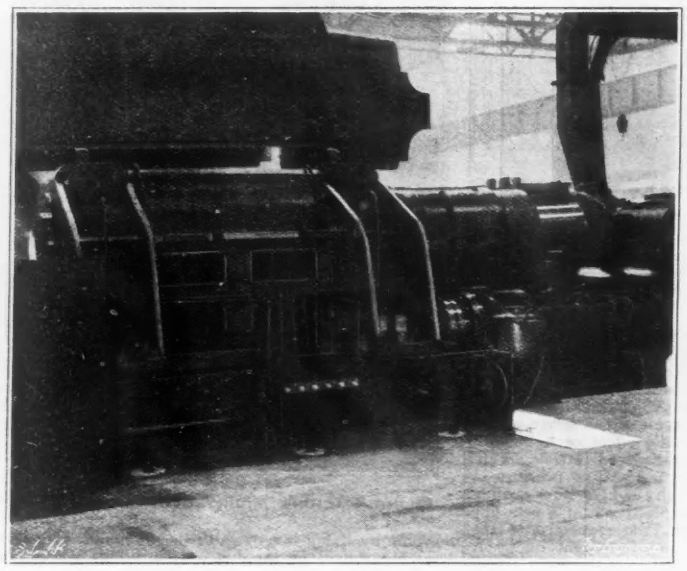


FIG. 11—*Pinion Housing with Cover Removed.*

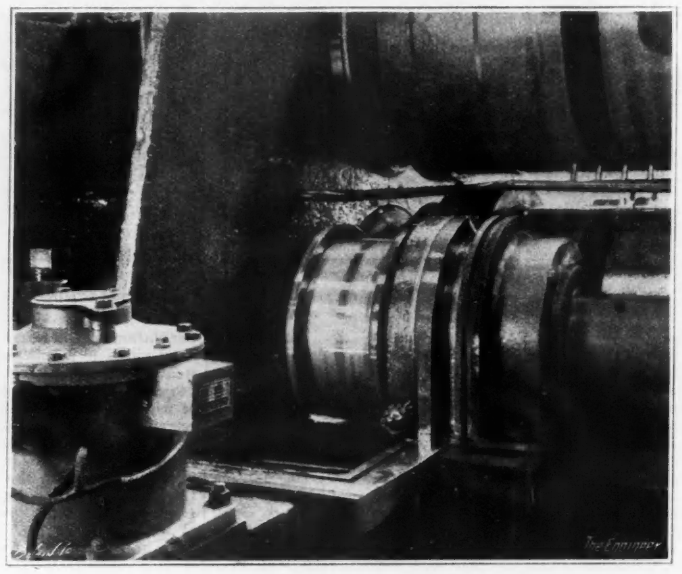


FIG. 12—*Friction Breast Roller Drive.*

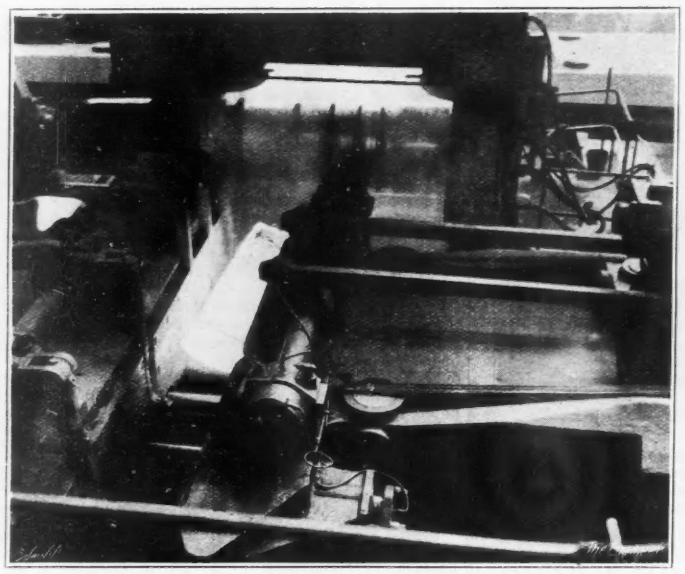


FIG. 13—*Turning-over Gear.*

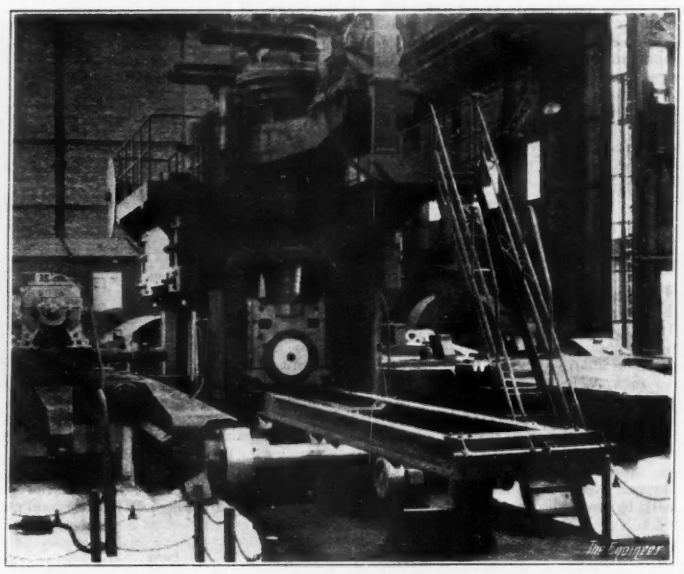


FIG. 14—*Roll Changing Carriage in Position.*

* Institution of Mechanical Engineers—Cardiff Summer Meeting, May 31st.

† Technical assistant to the managing director, Guest, Keen, Baldwins Iron and Steel Company, Ltd.

ingoing side is switched on, and then only until the ingot has been taken hold of by the rolls. It was suggested by the manufacturers that the solenoids should be operated by the position of the manipulators, switching off when they were opposite the third hole.

When this system is working as intended it is highly successful, as the drive is only operating at the moment required, thus saving power, and the rollers are always free or rotating in the same direction as the mill itself, thus making sure that the drive cannot be strained by an ingot issuing from the mill against the direction of rotation of the rollers.

Unfortunately, through a slight mistake in assembly,

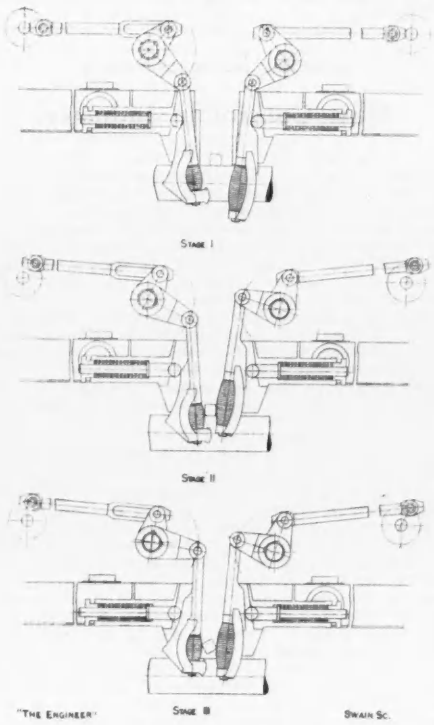


FIG. 15—*Device for Turning Over 5in. Blooms.*

at the start the whole of the pressure of the solenoids was concentrated on the pinion friction ring and none on the breast roller friction wheels, instead of being equally divided as it should have been. In consequence, the idle or jockey roller and the pinion friction ring wore badly, while the breast rollers lay dead. The mistake was soon discovered, and the drive reassembled correctly. Jockey rollers of a special bronze were put in and a big improvement was immediately apparent. It is still, however, not quite positive enough to satisfy the drivers, and improvements in this direction are now under consideration. In the Cardiff mill the drive is situated under the same oil hood as the spindles and pinions, and is practically running in oil. All other drives of this type previously built were outside the hood and not lubricated. It would seem unwise to lubricate a friction drive where the various members have only line contact, as the oil film can never be fully broken, fresh lubricant being fed in as the parts rotate.

It is probable that by shielding the drive from oil and using a slightly stronger solenoid, the desired effect will be obtained, as other drives operating on this system have been entirely successful.

The Manipulators.—Throughout the design of this mill the speed with which 5in. by 5in. blooms were to be rolled was never lost sight of. The electric drive of the manipulators was designed for such a rate of acceleration and braking as would ensure that it would not be the "bottleneck" in the process.

The front and back manipulators, photographs of which are reproduced in Figs. 9 and 10, page 650, are both coupled together. They slide on grease-lubricated surfaces, four to each head. The front end or end overhanging the roller gear is held down by gravity only. The back end is held down by slides on each side. The bolts holding these slides have springs under them, so that in the event of rough driving the back merely lifts up a little and falls back. A vertical roller runs in a slot across the roller run, and takes the end thrust should a bloom issuing from the mill catch in a slot in one of these heads. In addition, a rod fastened to the front and back of each head passes through a hole in the base plate. This hole has a powerful buffer spring in it and when the manipulator is overdriven, either forwards or backwards, a nut on this rod comes against this spring and absorbs the shock.

Despite all these safeguards, the unexpected occasionally

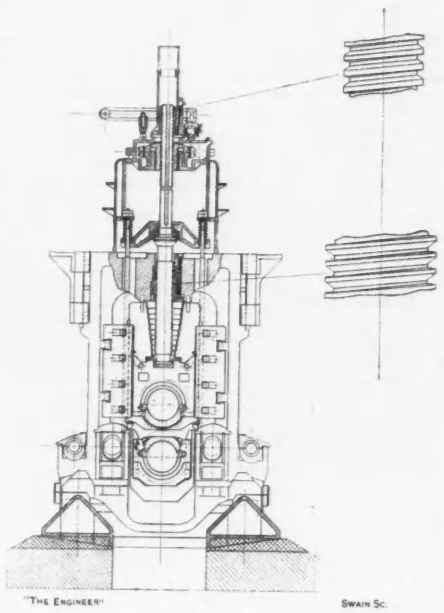


FIG. 17—*Arrangement of Screw-down Gear.*

happens. One day an ingot, issuing from the rolls, curved sharply round to one side, caught in a slot in the manipulator head, and threw the whole manipulator over to one side. The only damage was a bent tie rod. A new one was fitted and the eight bolts, with the springs under their nuts holding down the back end, were renewed, and in an hour the mill was rolling again.

One of the most important features of this manipulator is the Friemel device (Figs. 13 and 15) for turning over small blooms. It is used for sizes of 6in. by 6in. and under. It is so quick that a 5in. by 5½in. bloom may be turned as quickly and surely as a 10in. by 10in. bloom. It is largely this device which has enabled this mill to roll 5in. by 5in. blooms at such an astonishing speed.

The operator who drives the manipulators works the left-hand heads with his left hand, and the right-hand heads with his right hand, the normal turnover down to a size of 6in. by 6in. with his left foot, and the special device for turning small blooms with his right foot. The latter is arranged so that it comes up to the position shown in stage 2, Fig. 15, on pressing once with the foot, and goes back to stage 1 on pressing again.

During the first week or two the operator experienced some difficulty because the spring-loaded plunger behind the right-hand turnover was too close a fit and remained compressed. This left the arm hanging dead, and made it quite impossible to turn over a 5in. by 5in. bloom as was intended. It has been found essential to keep the serrations on the "cherries" very sharp, otherwise they slip on the bloom. These cherries rotate so that a new surface is being repeatedly brought to work.

The procedure when turning over a small bloom is as follows. The bloom is run back clear of the mill, and while it is coming back the operator drives the left-hand head back slightly, at the same time pressing his right foot and raising the right-hand "cherry" to stage 2. He then simultaneously drives the left-hand head to the right and presses his left foot. The bloom is squeezed between the two "cherries" by the compression of the plunger springs and at the same time rotated by the upward movement of the left-hand "cherry," the serrations on the right-hand "cherry" preventing the bloom from lifting bodily upwards. The left-hand cherry automatically comes back to stage 1 and the right-hand one is brought back by pressing his right foot.

The Screw-down.—It is a common sight in many blooming mills to see the bloom standing for several seconds on the roller run waiting for the screw-down. To ensure that this should never be the case at Cardiff, Ward-Leonard control was fitted.

The screw-down is driven by two heavy mill motors of 150 H.P. each, solidly coupled together and supplied in parallel with direct current from a special Ward-Leonard generator. The speed of the screw-down is controlled entirely by variation of the applied voltage on

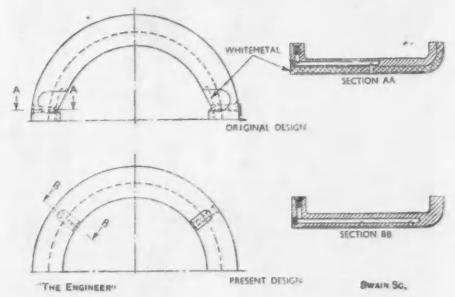


FIG. 19—*Detail of Bronze Bearings.*

the Ward-Leonard principle, and this scheme has been found thoroughly satisfactory and low in maintenance cost for a drive requiring such frequent operation and reversal—between forty and fifty movements of the screw-down occur when rolling one ingot.

To provide a standby, the Ward-Leonard set is duplicated and connected to change-over switches so that either set can be used at will. Each set consists of a 3300-volt, 335 H.P., 1000 r.p.m. slip-ring induction motor driving a direct current generator and exciter.

The Ward-Leonard control has been a complete success. There has never been any electrical trouble, and the speed is such that it cannot be said to be the limiting factor in the output of the mill. Although the control is extremely flexible, and it is possible to drive with great accuracy, trouble has occurred a few times due to screwing hard down and screwing hard up. The reason for screwing hard down is that the men have to drive the rolls within ¼in. of each other on certain passes and when they were trying to speed up they occasionally overdrove. Screwing hard up has only occurred once, and that was due to the control lever being accidentally knocked over. Owing to the narrow limits involved it was impossible to fit a limit switch in the downward direction, but one has now been fitted in the upward direction.

The arrangement of the screw-down gear is shown in Fig. 17. The drive is transmitted by a worm and worm wheel, the worm wheel having a keyed shaft sliding through it. The bottom of this shaft has a buttress thread taking the upward thrust due to the rolling pressure. The nut is inside the housing and has pump-fed grease lubrication. The lower portion of the thread is protected from dust by a telescopic metal sleeve. The bottom of the shaft transmits the thrust to the chock through a brass pad fitted into a cast steel shell. This brass pad is also grease lubricated. It is in no sense a "breaker" such as is fitted in many English mills, but merely a properly lubricated thrust block.

Above the top of this main buttress thread is a collar with a ball thrust bearing on it. On this bearing rests a yoke from which the top roll is hung on rods. The upper ends of these rods have springs by means of which the

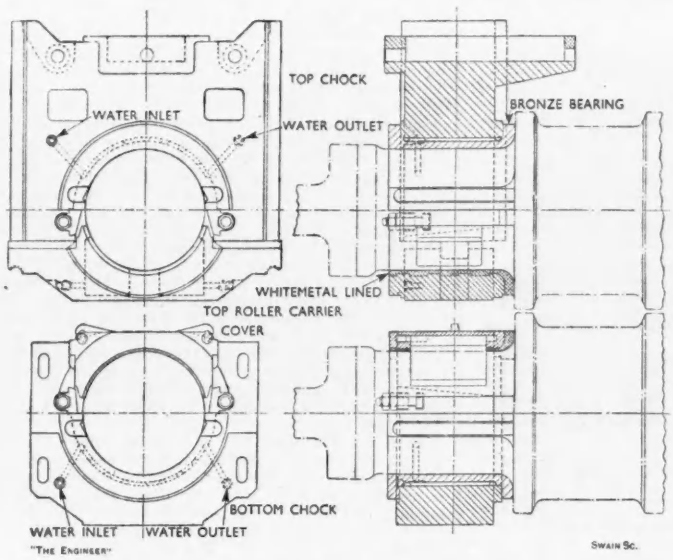


FIG. 16—*Arrangement of Chocks with Bronze Bearings.*

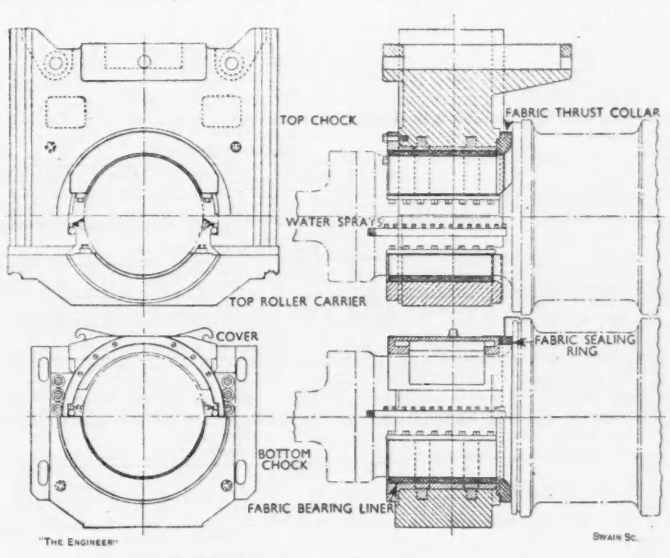


FIG. 18—*Arrangement of Chocks with Fabric Bearings.*

compression between the carrier and the top chock can be adjusted. The weight of the top roll thus comes on the main screw shafts. To carry this weight there is a buttress thread on the top of the shafts fitting in a nut supporting thrust in a downward direction only. This nut is carried in a sleeve supported by trunnions borne on a yoke. One end of this yoke rests on a spring, the other on an adjustable support which is hinged and can fold down, and at the extreme end of the yoke a crane hook can be inserted. In the event of the top chock being screwed hard up against the under side of the housing, the crane lifts this yoke and the support is folded, allowing the top nut and sleeve to come down until they rest on the

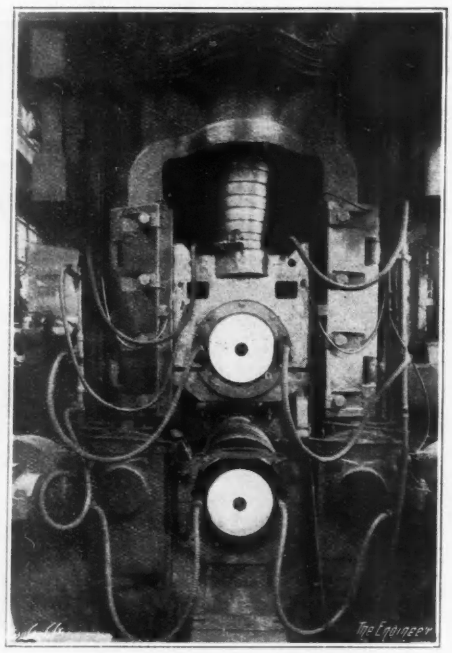


FIG. 20—*Water Connections to Fabric Bearings.*

worm wheel casing. On the occasion of the "screw-up" referred to, a small crane only was attached to the yoke and was unable to lift it; since then there has been a slight "screw-up" occasionally when roll changing. The 90-ton crane has been brought into use and this unloading device has worked most satisfactorily, the delay being only for a few minutes.

Changing rolls is still unfortunately a comparatively slow business, taking approximately five hours. The procedure is as follows:—The top roll is screwed until the upper ends of the rods supporting the top roll press against the casing, thus compressing the springs. The thrust block can now be pushed back in the pockets clear of the screw noses. The roll carriage—Fig. 14—is wound in by means of a winch. The roll is lowered until the carriers rest on the carriage. The cotter pins can now be removed from the suspension rods. The screw-down gear is now lifted steadily and the suspension rods engage in some projections on the main chocks, carrying them upwards till they can be hung from the housing by hooks. The roll can now be wound out on the carriage.

The Bearings.—The mill was originally fitted with brass bearings, with grease pump lubrication, fitting in cast steel chocks—Fig. 16—the carriers being lined with white metal. Fig. 19 shows how the grease holes were bored, and the small strip of white metal fitted at the bottom edge of each bearing. These bearings were not really satisfactory; the use of brass and white metal simultaneously did not give good results. The necks soon became fire cracked and wore the white metal carriers. The grease hole did not go far enough in towards the roll collar, and was also too near the bottom edge of the bearing, so that grease escaped freely. In addition, the white metal would spread and close up the grease holes.

The chocks were accordingly altered, the carriers being replaced with bronze blocks, and the main bearings made entirely of brass. The grease holes were bored further in to grease the collars, and further up from the bottom edge, so that the grease did not escape. This proved much more economical in grease, but the wear was still heavy and the rolls necks still cracked, even after experimenting with several greases. The total life of a brass varied from 100,000–130,000 tons according to its position.

In view of the successful results with fabric bearings in the light bar mill, where they had been fitted from the commencement, it was decided to change to fabric bearings in the blooming mill. They were fitted into the existing chocks after making a few slight alterations, Fig. 18. Scale guards were fitted to the bottom roll, filters were installed close to the mill, and large pipes connected to the ordinary mill water supply, as shown in Fig. 20. This gave about 18 lb. per square inch pressure on the mill side of the filter when everything was working.

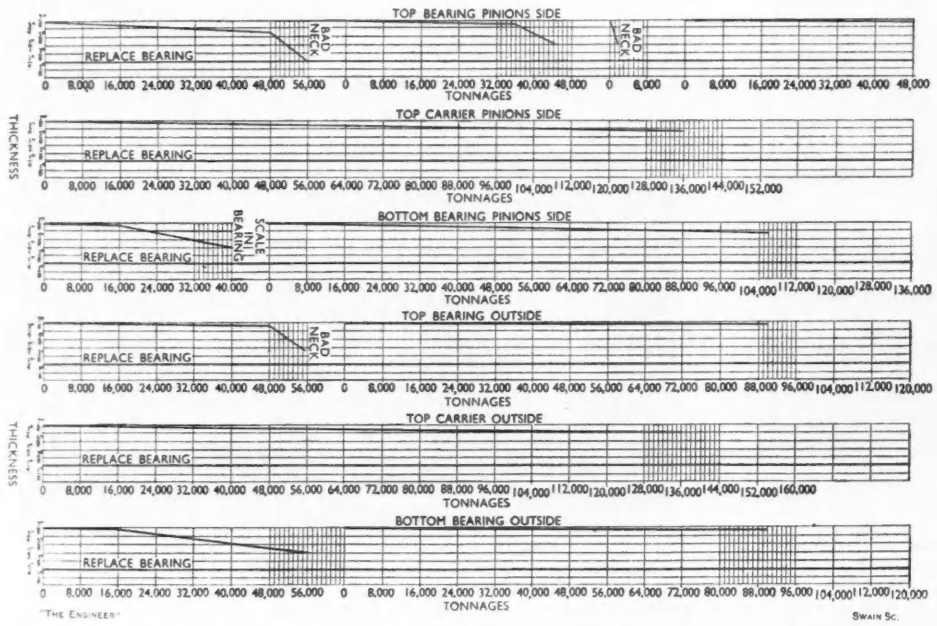
Table I shows the power consumed with both types of bearing. The fabric bearings give a saving of about 13 per cent. in power consumption. The power consumption for typical sections is as follows:—

TABLE I.—*Comparative Power Consumptions Using Bronze and Fabric Bearings.*

Week ending.	Bronze. Tons rolled	Units consumed.	Units per ton.
November 6th, 1937	6,449	139,420	21·6
November 13th, 1937	6,771	146,150	21·6
November 20th, 1937	8,365	165,630	19·8
November 27th, 1937	6,869	152,940	22·3
December 4th, 1937	8,036	158,130	19·7
December 11th, 1937	7,935	163,390	20·6
Total	44,425	925,660	125·6
Average	7,404	154,277	20·93
	Fabric. Tons rolled.	Units consumed.	Units per ton.
September 11th, 1937	7,654	134,360	17·5
September 18th, 1937	7,331	141,530	19·3
September 25th, 1937	7,518	136,160	18·1
October 2nd, 1937	6,281	116,330	18·5
October 9th, 1937	7,887	138,770	17·6
October 16th, 1937	6,906	127,870	18·5
Total	43,577	795,020	109·5
Average	7,263	132,503	18·25

Section, inches.	Power, electrical units per ton.
12×2¼	19·68
7×7	15·26
6×6	16·56
5×5	18·08

At first the bearings seemed completely satisfactory, the power consumption decreased and the wear seemed negligible. But after a few weeks trouble developed, and several bearings failed. No spares were at hand, so brass was temporarily resorted to again while several improvements were made. Two recording gauges were put in the control cabin showing the water pressure just before the nozzles on either side of the mill. By improving the connections a pressure of 30 lb. per square inch was obtained on the mill side of the filter. A routine examination is made at the end of each shift to see that all nozzles are clean, and to measure the wear of the bearings. The results are shown in Fig. 21. None of the replacement bearings has shown any sign of excessive wear.



Loads on brass bearings: top bearing, pinions side, 120 to 130,000 tons; top bearing outside, 120 to 130,000 tons; both bottom bearings, 100,000 tons.

FIG. 21—*Curves of Wear with Fabric Bearings* (40*in. Mill*).

The reasons for the early failures are not easy to discover, except in one case, where failure was definitely due to the neck having been spoilt by the failure of a previous bearing. The other failures may have been due to low water pressure, or to the water not having been turned on properly. It would appear that bearings on the pinion side should last for about 500,000 tons and those on the outside for about 1,000,000 tons. To obtain even better results it is probable that it would be better to have the necks ground, and perhaps to use even higher water pressure.

(To be continued.)

Dust Control in Industry.

By T. C. ANGUS.*

HAZARDS to the health of industrial workers caused by the breathing of air-borne fumes and dusts may be considered to fall under two headings—first, such as result from known poisonous substances, and secondly, such dangers that may result from the breathing of other dusts which are not considered to be toxic in the usual sense. Under the first classification come dusts from a material such as lead and fumes from molten metals—giving rise to types of specific poisoning so well known as now to be capable of immediate recognition and efficient control. Under the second heading, hazards due to the inhalation of non-poisonous dusts, we have perhaps a more insidious problem and certainly one that was much later to be recognised than the hazards of phosphorus or lead working.

In this country the most serious causation of pneumonoconiosis, or damage to the lungs, is to be found in dusts containing free silica and asbestos dust. Free silica occurs in the dust produced in quarrying and working granite and sandstone, grinding with natural abrasives, certain classes of pottery, foundry work, and in some, but not all, coal mines. The damage done to the lungs of persons breathing these dusts often takes years to become evident, and is due to some action not yet fully understood. But the fact that the damage occurs in the innermost parts of the lungs entails that the dust particles must be sufficiently small to be suspended in the air for some minutes and carried to the noses of the workers by draughts. The rate at which very small particles will fall through still air, or, in other words, the time for which they will remain suspended, depends more upon their size than upon their density. It is now generally accepted that particles above 10 microns ($^{10}/_{1000}$ mm.) in diameter are unlikely to cause damage to the lungs because they will fall to earth before they are likely to be breathed. Quartz particles of 5 microns, on the other hand, have a theoretical rate of fall of only 1·5 mm. per second in still air; in the absence of a proper ventilation system they can be carried to almost any distance by fortuitous air currents and become a potential source of danger.

The mechanisms by which such dusts as those of silica and asbestos cause damage to persons' lungs are still obscure; expert opinions differ, but it is reasonably certain to say that the damage is not caused by any mechanical abrasion or cutting due to the hardness and sharpness of the particles.

When the average diameter of the particles in a dust cloud may be less than 2 microns, it is fairly apparent that the minute cutting edges such particles will present have little effect on the soft and fluid-covered surfaces of the alveoli, particularly as there is not likely to be any grinding action therein to cause abrasion. In this connection it is interesting to note that one method used by engineers to protect the surfaces of steel fan blades from the abrasive action of dust passing over them at high velocity is to coat the fan blades with rubber. Even more convincing is the fact that dusts composed of artificial abrasives, silicon carbides, appear to cause no pneumonoconiosis, although, as is well known, carborundum is a much harder and sharper material than either Yorkshire grit or granite. The dusts from both of the last-named materials are notorious sources of silicosis. Again, it has recently been shown that freshly produced silica dust has a considerable solubility in water.

All of these facts point to a chemical rather than to a mechanical action taking place in lungs subjected to these dusts and causing them damage; but although authorities still disagree as to the details of the damaging processes that take place, the immediate problem facing the industrial medical officer and the engineer is unaffected. This problem is to protect the noses and mouths of persons working with materials that produce dangerous dusts from inhaling dust concentrations above what is believed to be a safe limit.

When the Factories Act, 1937, comes into force, the existing regulations concerning dust will be strengthened. All practicable measures will have to be taken to protect the workers against breathing dust, fume, or other impurity and to prevent it accumulating in a workroom, if it be of a character likely to be injurious or offensive to the persons employed. The same requirements will apply to places where "any substantial quantity of dust of any kind" occurs.

It is safe to predict that it will never be practicable entirely to eliminate all dust from the air of a works in which dust-producing materials are being worked or stored, but what can be done is to control the dustiness of the air breathed to within safe limits, and such a control postulates some means to measure the dust concentration in the air so that the effectiveness or otherwise of exhaust apparatus and the like may be determined.

SAILPLANE HEIGHT RECORD.—A new British altitude record for sailplanes has been set up by Mr. Philip Wells, who reached a height of 10,000ft. near Dunstable recently.

* Department of Industrial Physiology, London School of Hygiene and Tropical Medicine.—Extract from article in *Industrial Welfare*, May, 1938.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The International Steel Situation.

The international iron and steel markets are still suffering from the delay in the renewal of the Cartel agreements which are due to expire on June 30th. It is expected, however, that the difficulties will be solved before the Cartel meeting which is due to take place on June 16th, and that the agreements prolonging the Cartel for a further period of three years will then be signed. The mere possibility that the Cartel organisation will break down has been sufficient to deter buyers all over the world from placing more orders than they can help. The general view is that failure to reconstitute the Cartel would be followed by a period of intensive competition. The situation in the iron and steel industries in most of the European countries has deteriorated considerably during the past few months. In Great Britain a curtailment of production has been forced upon the works by the slackening in demand, and although the output of most descriptions of heavy steel is still at a high rate, it shows a marked decline from the level of the earlier months of this year. Export business in British steel is also difficult to arrange, notwithstanding the advantages which the producers of this country have as a result of tariff agreements with British Empire markets. The situation in Germany appears to be more satisfactory than in other Continental countries, principally owing to the clearing arrangements with some of the principal iron and steel-consuming countries. These include South Africa, New Zealand, and Canada, amongst Empire markets, and a number of foreign countries. In Belgium the steel works are badly off for orders and are kept in operation largely by business passed to them by the Luxemburg steel works with the consent of the Cartel. The Belgian home market has provided valuable orders for the mills chiefly from Government, municipal, and railway development schemes. Although the Luxemburg industry has given up orders to the Belgians, it is not too well employed itself. It is understood, however, to have more export orders on its books than the Belgian works. The French works appear to be struggling against adverse conditions. There was a fear at one time that the depreciation of the franc would be followed by an attempt on the part of the French makers to secure overseas business by cutting their export quotations. The official quotations, however, have been fairly well maintained, and the competitive power of the French industry seems to have been undermined by the introduction of the forty-hour week.

The Pig Iron Market.

There has been practically no trading in the pig iron market this week, partly owing to the Whitsun Holiday. Many consuming firms took advantage of the break to suspend deliveries as the stocks in hand already totalled more than they could conveniently accommodate, and this, of course, resulted in additions to the stocks at the makers' yards. The amount of new business passing in the foundry iron market has been negligible, and the announcement that prices will be held at their present levels until the end of the year does not appear to have influenced consumers in giving out fresh orders. Doubts are openly expressed of the policy of the producers in maintaining their quotations, and some at least amongst the light castings makers would like to see a reduction in the price of pig iron so that they could lower their quotations for their finished products. Such demand as exists at the moment is principally from the engineering industries, and for special quality iron from the motor car manufacturers. The prices of the latter descriptions of iron are not controlled, and during the past few weeks there has been some decline in quotations, which has brought them more into line with consumers' views. A reduction in output is proceeding and furnaces of an old pattern which were started up at the time of scarcity last year are now being put out of commission. Most of these units were engaged on the production of basic and hematite iron, although there has been some curtailment of foundry iron production. On the North-East Coast the stocks of foundry iron are increasing, and in some instances consumers have postponed deliveries. There has been little demand for Midland irons, and until there is an improvement in the situation at the foundries the position is likely to remain unsatisfactory. Similar conditions appear to be developing in Scotland and iron is being stocked on an inconveniently large scale. The steel makers are still using large quantities of hematite, but most of the deliveries now taking place are against old contracts and little new business is being transacted. There is practically no export business in any description of pig iron, as foreign makers quote prices well below the British levels. Unsatisfactory conditions also rule in the basic iron department and most of the steel works have far more on their hands than they can manage with comfort. The production of this class of iron will probably show a sharp decline when the next statistics are issued, since the growth of stocks is taking place at a time when the demand for steel is falling.

Scotland and the North.

The decline in new business which has been in evidence for so long is having a noticeable effect upon operations at some of the Scottish steel works, and the steady decrease in the reserve of work has reached a point at which some of the mills have been compelled to curtail operations. The steel trade, however, has been encouraged by the placing of one or two orders for merchant vessels and, at the same time, specifications for steel against old contracts are reaching the works on a fairly satisfactory scale. Good deliveries of plates are being made, and although there has been a considerable shortening in the periods required for delivery the demand for this class of steel has been rather better than for most descriptions. Large tonnages of material are being produced and delivered to the shipyards, although, unfortunately, by far the greater part consists of deliveries against old contracts. Business in structural steel shows signs of declining; but one or two good contracts have been obtained lately, one being for 22,000 tons of steel bars of a special design, which is reported to have been placed with Colvilles, Ltd., by a firm of public works contractors. The re-rolling firms in Scotland continue to suffer from a restricted demand and heavy stocks at most of the consumers' works. Operations are upon a restricted scale and the demand is most active for reinforcing rods. The request for wrought iron has been on a limited scale and the outlook in this department does not seem particularly favourable. A good deal of short time is being worked in this industry and prompt delivery can be obtained from most of the works. Little interest has been shown by consumers in the Lancashire iron and steel market and whilst this may be due partly to the interruption of the Whitsun holiday, it is also a symptom of the steady decline in the demand which has been proceeding for the past few months. Producers are seeking new business, but users are chary of committing themselves, since, notwithstanding all assertions to the contrary, they believe there is a possibility that prices will be reduced before the end of the year. It is probable that any development calculated to revive the demand for steel would be quickly reflected in a rush to place new orders. There is only a light demand for re-rolled bars and little business is being received from the nut and bolt makers, who are carrying large reserve stocks. The request for bright steel bars is moderate, but business in special steels has declined. Similar conditions prevail on the North-West Coast, although the works there still have a considerable tonnage of orders in hand.

The Midlands and South Wales.

The Midland steel trade is feeling the effects of the recession in the demand, and recently operations at some of the important works have been curtailed. The Whitsun holidays were prolonged as a result of the quiet trading conditions for a longer period than for several years past. The demand for structural steel has declined considerably since the beginning of the year, but recently contracts for one or two hangars in connection with the rearmament programme have been given out, and the orders for steel resulting from these have made welcome additions to the works' books. Most of the steel producers still have a considerable tonnage of orders to execute, but lately, in a number of cases, consumers have asked for deliveries to be suspended. Several Midland re-rolling works are employed part time, and some of them are operating only three days a week. The heavy congestion of steel materials of the description produced by this branch of the industry resulting from imports and the rather excessive production of the early months of the year, is being slowly absorbed, but it will be some time before anything like normal conditions are restored to the market. One of the brightest features in the steel situation is the active demand for colliery steel. The production of this class of material is maintained at a good rate, and it seems likely to be continued as the supplies to the collieries had fallen into arrears during the period of stringency. Business in steel sheets has been very irregular, but the demand from the motor industry for special sorts has improved a little during the past week or two. For ordinary grades of sheets there is only a poor request. No surprise was occasioned by the announcement that the British Wrought Iron Association had decided to stabilise its prices for wrought iron and No. 3 and No. 4 bars until December 31st, 1938. This industry is not in a good position and practically all the works are in need of orders. The decision of the pig iron makers to maintain their prices for forge iron unaltered, however, left the bar iron makers no option but to follow suit. In the South Wales market the tinplate industry is operating at about 35·50 per cent. of capacity, and this has reacted upon the demand for steel. Only about 46 per cent. of the melting furnaces in that district are in operation.

Current Business.

The New Zealand Government placed contracts with British engineering manufacturing firms during May totalling £193,000. These included an order for ten Diesel mechanical railcars, valued at £89,500, placed with the Vulcan Foundry, Ltd., Newton-le-Willows, Lancs.; steel for bridge construction, valued at £15,000, with Dorman, Long and Co., Ltd., Middlesbrough, the Cargo Fleet Iron Company, Ltd., Middlesbrough, Guest, Keen and Baldwins, Ltd., Cardiff, and the Steel Company of Scotland, Ltd., Glasgow. A contract for pig iron was secured by Carron Company, Ltd., Falkirk, valued at £10,750, and contracts with Lancashire and Yorkshire firms to a total of £16,800 for steel plates, disc wheels, spring steel, steel tyres and axles; and for railway switchgear, protectors, fuse mountings, and bronze bushes valued at £7000 with Birmingham and Coventry firms. Rose, Downs and Thompson, Ltd., engineers, Hull, have just opened extensions to their works at Old Foundry, comprising a new welding and steel fabricating shop which is equipped with modern plate working and welding plant. The firm has been in existence since 1777. The Whiteley-Read Engineers Limited, a subsidiary of William Watts, Ltd., constructional engineers and gear makers, have opened new works at Park-lane, Basford, Nottingham. Orders for two cargo steamers of 6200 tons gross each have been secured by Lithgows, Ltd., Port Glasgow, from T. and J. Harrison, Ltd., Liverpool. The machinery will be built by David Rowan and Co., Ltd., Glasgow. A contract for the supply of 12,053 tons of railway chairs for the South African Railways has been obtained by Head, Wrightson and Co., Ltd., Thornaby-on-Tees. Alexander Stephen and Sons, Ltd., Linthouse, Glasgow, has obtained an order for a cargo motorship of 6000 tons gross for the New Zealand Government. The propelling machinery will be supplied by Barclay, Curle and Co., Ltd., Whiteinch. The Department of Overseas Trade announces that the following contracts are open for tender:—South African Railways and Harbours Administration: Supply and delivery of 5-ton, four-wheeled welded frame timber trailers (Johannesburg, August 8th). Johannesburg City Council: 1000 metal lockers, approximately 36in. long, 14in. high, and 17in. deep, fitted with door, hasp and staple (Johannesburg, June 15th). Pretoria, Public Works Department: Vertical-spindle bore-hole pump, complete with either squirrel-cage or slip-ring motor and switchgear, valves, and pipe fittings (South Africa, June 16th).

Copper and Tin.

The rather firmer conditions ruling on Wall-street appear to have created a better feeling in other departments in the United States, including the non-ferrous metal markets. After the holidays the electrolytic copper market opened with a stronger tone than had been in evidence for some time. According to reports American consumers are showing greater interest in the market, and as it has long been evident that until buying on a more substantial scale developed in the United States the copper market could not show any permanent improvement this has been taken to indicate that more cheerful conditions may be at hand. The paucity of American buying is shown by the low tonnage of the domestic sales during May, which reached only 19,000 tons. When it is remembered that thirty years ago consumption in America was 30,000 tons per month and that since then there has been an enormous increase in the country's consumptive capacity, the extent of the drop in the demand can be understood. Business in Europe has been interrupted by the Whitsun holidays, but there was a fair amount of buying when the markets reopened. A feature of the metal lately has been some good buying by India, which has been practically dead for some time. In the London standard market speculation has once more developed, and a small bull account appears to have been built up. This revival of interest on the part of speculators is an indication that the market thinks that the course of prices may be about to turn. . . . Immediately before the holidays the International Tin Committee held a meeting in Paris to consider the results of the referendum of the Malayan producers on the question of establishing a Buffer Pool. As this was satisfactory the Committee has decided to fix the quota for the third quarter of 1938 at 45 per cent. of the standard tonnage, which was increased in the case of Malaya, the Netherlands, and the East Indies by an additional 7½ per cent. of the standard tonnages. From this standard quota of 45 per cent. such percentage as the Committee may determine later will be allocated towards the formation of a Buffer stock. The Committee, it is stated, have already agreed to a skeleton scheme which has been submitted to the signatory Governments, and will draft a complete scheme as rapidly as possible, taking account of the observations and suggestions which certain signatory Governments have made. It is anticipated that the complete scheme will be placed before a special meeting of the Committee to be held before July 1st. In view of this announcement the market opened firm, but was rather inactive. The statistics published by the International Tin Research and Development Council give the production of tin in the first quarter of 1938 as 43,200 tons compared with 46,200 tons in the corresponding period of 1937. The world consumption in the first quarter was 40,700 tons compared with 51,000 tons in the same period of 1937. Consumption seems to have fallen in the United States, Great Britain, France, Holland, Czechoslovakia and Belgium, but has increased in Germany, Italy, Japan, Poland and Sweden.

Lead and Spelter.

Conditions in the lead market have shown some improvement lately partly as a result of the stronger conditions which have developed in the copper market. This influence is entirely sentimental, but it has had the effect of restoring a certain amount of confidence which had been lacking for some time. As is usually the case immediately before and after a holiday, there has been little buying on the part of consumers, but, on the other hand, there has been less disposition to offer metal on the market. In mid-week there was a tendency on the part of users to cover their nearby requirements, although the actual volume of business was not large. Substantial quantities of lead continue to pass into consumption, but supplies are plentiful. The cable-making industry is probably still the largest consumer, but lately there have been indications that the demand from this source may not be maintained at its present level. The quantity of lead passing into use in the form of pipes and sheets is still satisfactory. Latterly a good outlet has been provided by work in connection with rearmament, and this has helped to support prices. For the time being this market appears to have fallen into a rut, and whilst on the whole conditions remain satisfactory, there is a marked absence of speculative interest, probably because, although prices may be low, the outlook in the market does not encourage operations of a speculative character. . . . With the turn for the better in the non-ferrous metal markets a more active demand for spelter has developed from consumers, who have been holding off or buying in small parcels. Supplies, however, have been on a rather full scale and the volume of buying has not been sufficient to impart real stability to prices which in mid-week showed a tendency to fluctuate. There have been some arrivals of Continental spelter and more is expected during the month. On the other hand, the brass trade continues to take good quantities, but there seems to be a slackening in the requirements of most of the consuming industries and the poor trading conditions which are being experienced by the galvanisers continue to exert an adverse influence upon the spelter market.

Current Prices for Metals and Fuels.

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from associated British Steelmakers. †Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-.

	Home. (D/d Teesside Area.) £ s. d.	Export. £ s. d.
N.E. COAST—		
Hematite Mixed Nos.	6 12 6	—
„ No. 1	6 13 0	7 7 6
Cleveland—		
No. 1	5 11 6	6 2 6
No. 3 G.M.B.	5 9 0	6 0 0
No. 4 Foundry	5 10 0	5 19 0
Basic	5 0 0	—
MIDLANDS—		
Staffs— (Delivered to Black Country Station.)		
North Staffs. Foundry	5 11 0	—
„ „ Forge	5 6 0	—
Basic	5 0 0 to £5 5 0	—
Northampton—		
Foundry No. 3	5 8 6	—
Forge	5 5 6	—
Derbyshire—		
No. 3 Foundry	5 11 0	—
Forge	5 8 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	6 13 0	—
No. 1 Foundry, ditto	6 0 6	—
No. 3 Foundry, ditto	5 18 0	—
Basic, d/d	5 7 6	—
N.W. COAST— Hematite Mixed Nos.	6 13 0 d/d Glasgow; 6 18 6 „ Sheffield; 7 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
LANCS AND YORKS—		
Crown Bars	13 5 0	—
Best Bars	13 15 0	—
MIDLANDS—		
Crown Bars	13 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	11 12 6	—
No. 4 Quality	12 2 6	—
SCOTLAND—		
Crown Bars	13 5 0	13 5 0
Best	13 15 0	13 15 0
N.E. COAST—		
Crown Bars	13 5 0	13 5 0
Best Bars	13 15 0	13 15 0
Double Best Bars	14 5 0	14 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	13 17 6	—

STEEL.

	*Home. £ s. d.	†Export. £ s. d.
LONDON AND THE SOUTH—		
Angles	11 3 0	10 12 6
Tees	12 3 0	11 12 6
Joists	11 3 0	10 12 6
Channels	11 8 0	10 17 6
Rounds, 3in. and up	12 3 0	11 12 6
„ under 3in.	12 15 6‡	11 0 0
Flats, under 5in.	12 15 6‡	11 0 0
Plates, ¾in. (basis)	11 13 0	11 0 0
„ ⅛in.	11 18 0	11 5 0
„ ¼in.	12 3 0	11 10 0
„ ⅜in.	12 8 0	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	12 3 0	12 2 0
NORTH-EAST COAST—		
Angles	11 0 6	10 12 6
Tees	12 0 6	11 10 0
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 8 0	11 0 0
„ ⅛in.	11 13 0	11 5 0
„ ¼in.	11 18 0	11 10 0
„ ⅜in.	12 3 0	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	11 18 0	12 2 0
MIDLANDS, AND LEEDS AND DISTRICT—		
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 10 6	11 0 0
„ ⅛in.	11 15 6	11 5 0
„ ¼in.	12 0 6	11 10 0
„ ⅜in.	12 5 6	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	12 0 6	12 2 6

STEEL (*continued*).

	*Home. £ s. d.	†Export. £ s. d.
GLASGOW AND DISTRICT—		
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	11 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 8 0	11 0 0
„ ⅛in.	11 13 0	11 5 0
„ ¼in.	11 18 0	11 10 0
„ ⅜in.	12 3 0	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	11 18 0	12 2 6
SOUTH WALES AREA—		
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 10 6	11 0 0
„ ⅛in.	11 15 6	11 5 6
„ ¼in.	12 0 6	11 10 0
„ ⅜in.	12 5 6	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G)	12 10 0	12 2 6

IRELAND—F.O.Q.—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	11 5 6	11 8 0
Tees	12 5 6	12 8 0
Joists	11 5 6	11 15 6
Channels	11 10 6	11 13 0
Rounds, 3in. and up	12 5 6	12 8 0
„ under 3in.	12 18 0‡	13 0 6
Plates, ¾in. (basis)	11 13 0	11 15 6
⅛in.	11 18 0	12 0 6
¼in.	12 3 0	12 5 6
⅜in.	12 10 0	12 10 0
Un. ⅛in. to ¼in. incl.	12 3 0	12 5 6

‡ *Rounds and Flats tested quality; untested 9/- less.*

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. f.o.b. £ s. d.
11-G. and 12-G., d/d	14 15 0	11-G. to 14-G 12 10 0
13-G., d/d	15 2 6	
14-G. to 20-G., d/d	15 10 0	15-G. to 20-G 12 15 0
21-G. to 24-G., d/d	15 15 0	21-G. to 24-G 13 0 0
25-G. and 26-G., d/d	16 10 0	25 and 26-G. 13 15 0

South Africa, Rhodesia, Nyasaland £14; Canada £14 12s. 6d. f.o.b. basis. Irish Free State, £15 15s., f.o.q., four-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10 cwt., £2 per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.—

Home.	£ s. d.
4-ton lots and up	18 10 0
2-ton to 4-ton lots	18 17 6
Under 2 tons	20 2 6

Export; India, £18 15s. c.i.f.; Irish Free State, £18 10s. f.o.q.; General, £16 15s. f.o.b., 24-G. basis.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 20/3 to 21/6.

Tin-plate Bars, d/d Welsh Works, £7 15s.

Billets. 100-ton lots and over, 35 to 100 tons, 5/- extra: less than 35 tons, 10/- extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 17 6
„ „ „ tested	8 7 6
Basic (0·33% to 0·41% C.)	8 12 6
„ Medium (0·42 to 0·60% C.)	9 2 6
„ Hard (0·61% to 0·85% C.)	9 12 6
„ „ (0·88% to 0·99% C.)	10 2 6
„ „ (over 0·99% C.)	10 12 6
Rails. Heavy, 500-ton lots, f.o.t.	10 2 6
„ Light, f.o.t.	9 2 6

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro Tungsten	4/8 per lb. (nominal)	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 5 0	7/6
„ „ 6 p.c. to 8 p.c.	£24 0 0	7/6
„ „ 8 p.c. to 10 p.c.	£24 0 0	7/6
„ „ Max. 2 p.c. carbon	£36 0 0	11/-
„ „ „ 1 p.c. carbon	£38 5 0	11/-
„ „ „ 0·50 p.c. carbon	£41 0 0	12/-
„ „ „ carbon-free	1/- per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£18 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 0 0 scale 6/- p.u.	
„ Vanadium	14/- per lb.	
„ Molybdenum	4/9 per lb.; 5/- forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton.	
Cobalt	8/6 to 9/6 per lb.	

NON-FERROUS METALS.

(*Official Prices, June 8th.*)

COPPER—	
Cash	£34 8 9 to £34 10 0
Three Months	£34 13 9 to £34 15 0
Electrolytic	£38 10 0 to £39 10 0
Best Selected Ingots, d/d Birmingham	£39 5 0
Sheets, Hot Rolled	£70 0 0

	Home.	Export.
Tubes, Solid Drawn (basis)	11¾d.	11¾d.
„ Brazed (basis)	12d.	12d.

BRASS—	
Ingots, 70/30, d/d Birmingham	£33 10 0

	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	10¾d.	10¾d.
„ Brazed	12¾d.	12¾d.

TIN—	
Cash	£171 5 0 to £171 10 0
Three Months	£171 15 0 to £172 0 0
SPELTER—	
Cash	£12 7 6 to £12 8 9
Three Months	£12 11 3 to £12 12 6
LEAD—	
Cash	£13 6 3 to £13 8 9
Three Months	£13 10 0 to £13 11 3
Aluminium Ingots (British)	£100 to £105

FUELS.

SCOTLAND.

	Export
LANARKSHIRE—	
(f.o.b. Grangemouth)—	
Navigation Unscreened	18/6 to 19/-
Hamilton Ell	17/6
Splints	20/-
AYRSHIRE—	
(f.o.b. Ports)—Steam	15/9 to 16/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	17/6
Unscreened Navigation	18/- to 19
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	17/-
Secondary Steam	16/6

ENGLAND.

SOUTH YORKSHIRE, HULL—	
B.S.Y. Hards	21/6 to 22/-
Steam Screened	19/- to 19/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/3 to 18/6
„ Second	18/-
„ Best Small	17/6
Unscreened	18/- to 19/-
DURHAM—	
Best Gas	21/-
Foundry Coke	29/- to 35/-

SHEFFIELD—	Inland.
Best Hand-picked Branch	28/- to 29/6 —
South Yorkshire	25/6 to 27/- —
Seconds	22/- to 24/- —

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	24/- to 24/6
Best Seconds	24/-
Best Dry Large	23/6 to 24/-
Ordinaries	23/6 to 24/-
Bunker Smalls	17/6 to 19/-
Cargo Smalls	16/6 to 17/6
Dry Nuts	24/6 to 26/-
Foundry Coke	37/6 to 55/-
Furnace Coke	28/- to 30/-
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	38/- to 41/-
Machine-made Cobbles	41/- to 51/-
Nuts	40/- to 50/-
Beans	33/- to 38/6
Peas	26/- to 29/6
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	20/- to 25/-

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon
Furnace Oil (0·950 gravity)	3¾d.
Diesel Oil	4½d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Compulsory Apprenticeship.

THE problem of apprenticeship has only been dealt with in one of its aspects by the recent decree fixing the conditions under which all youths between the ages of fourteen and seventeen years, excepting those being trained for particular occupations under the responsibility of their parents, must attend technical classes and be sent into trades suited to them. It is a development of the existing system of private, municipal, and other technical schools, most of which are intended for particular trades, and the object of the new arrangement is to organise the system under the control of the State and render it compulsory. In each department, which has some equivalent to a county, there is to be a State school of "professional selection," or, in other words, youths will follow classes in order to ascertain their aptitudes and abilities and their physical condition. It is not intended to suppress existing private technical schools, and new schools may be established on condition that they offer a guarantee of efficiency, while municipalities are encouraged to continue their co-operation by the same means. All initiative in this work will be taken into account. There will also be departmental and regional secretarial organisations which will control and co-ordinate the State and private "centres of professional orientation," as they are called, and serve as connecting links between the State and private schools and between them and the labour exchanges. The work of these secretarial departments will be wide and comprehensive, and will ensure that all youths within the prescribed age limits attend the schools, excepting those exempted by arrangement with their parents. The secretarial departments will also be responsible for the granting of certificates to youths indicating the trades for which they are suited, this being done after consultation with the schools. A period of three years is allowed to carry out this organisation, after which time no youth below seventeen years of age can be employed in an industrial or commercial undertaking without a certificate. Not only is there to be compulsory attendance at technical schools of youths between fourteen and seventeen years who are not employed, but also of youths less than eighteen years old employed in trade and industry, so that the organisation leaves no loophole for escape in the case of youths who are not being trained independently. Attendance at technical schools must be for at least 150 hours a year.

Practical Training.

The preliminary apprenticeship, or pre-apprenticeship, is both theoretical and practical, and is intended primarily to draft youths into trades for which they appear to be suited; but it is obviously impracticable to turn out more candidates for practical apprenticeship than are needed in some industries and less than are required in others. It is therefore proposed in a forthcoming decree to fix, every five years, the minimum proportion of apprentices to the total number of workers and employees in each trade. The pre-apprenticeship must take account of these requirements. There is every indication that the practical training will be on the lines explained in a recent note dealing with the conditions of apprenticeship in the collective contract with the Paris aircraft engine builders. They must train apprentices without the option of paying taxes for the maintenance of schools for that purpose. If this training is imposed on all employers it will meet with opposition from a considerable number of them, especially from small employers who cannot take apprentices in their shops so long as the existing law makes a distinction between them and the men in the number of working hours, and introduces complications and a severe control by factory inspectors. It is also objected that a compulsory pre-apprenticeship may fail in its object of selecting youths according to their supposed suitability for particular trades at an age when it is usually impossible to say in what direction their preferences and abilities will be revealed later on. The Government affirms that the new system will not interfere with the freedom of workers and employers or with parents, and that the compulsion of pre-apprenticeship does not apply to the choice of a trade, but to a "consultation," meaning, presumably, that the views of parents will be considered; but in whatever manner the system is applied, it will necessarily mean the creation of a vast administrative organisation which will give an effective monopoly to the State, with, it is promised, tolerance to private initiative, although experience of the past two years leaves employers dubious as to the extent of that tolerance.

The Canal du Nord.

Another of the periodical attempts to complete the Canal du Nord is being made by industrial interests in the northern departments with parliamentary support, and a recently formed committee has visited the abandoned works which have been left derelict since the war. The canal was to have connected the Pas-de-Calais with Paris by way of the Somme and the Oise, and its width of 55ft. 8in. and depth of 8ft. 2in. would have allowed 600-ton barges to make good time over the 59 miles at low cost. Work upon it was begun in 1907, and when the war broke out 20 miles had been completed and as much again was well advanced. During the hostilities practically everything was destroyed, and although the canal was to have been reconstructed with reparation payments, the money was not forthcoming, and any hope of completing the canal appeared to have been abandoned a few years ago when the Government turned down the proposal to complete the canal with a smaller section, on account of the cost, for barges of 300 tons. It is doubtful whether this new attempt to revive the enterprise by bringing it within the programme of public works will meet with better success, for it is estimated that the minimum total expenditure would be 500 million francs, and while it would provide a more rapid waterway communication between the north and Paris, there is more urgent work to be done with the State funds. If the canal is abandoned there will be the problem of undoing all the work and filling it at considerable cost.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

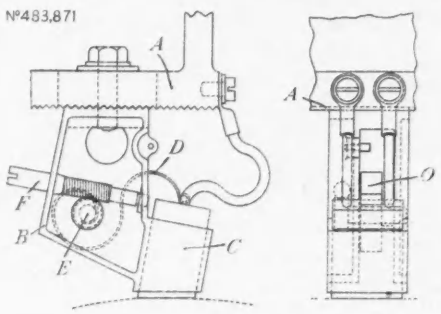
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton-buildings, Chancery-lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

483,871. February 4th, 1937.—BRUSH GEAR, Gustaf Adolf Juhlin, "Redscar," Moss-lane, Timperley; and Metropolitan-Vickers Electrical Company, Ltd., 1, Kingsway, London, W.C.2.

The object of the invention is to provide an improved construction in which provision is made for readily staggering individual brushes of the same group around the commutator and for securely clamping the brushes in the positions to which they have been adjusted. A brush arm A mounted above the commutator has a brush holder B, which includes a brush box C housing a brush. B is clamped against the serrated under-surface A by means of a clamping bolt which passes through an elongated slot in the brush arm, so that by slackening the nut on the bolt the brush holder may be adjusted sideways, having the effect of moving the brush around the commutator.

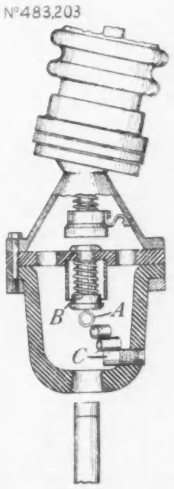


When the brush is in the desired position the nut is tightened and the serrations then hold the brush holder in position. D is a spring for applying pressure to the brush. The end of the spring is secured to a rod E which is rotatable from an adjustment member F acting through a worm gear so as to adjust the spring tension. In the arrangement shown the general plane of the under-surface of A would be substantially parallel with the tangent to the commutator surface at the point of brush contact. Alternatively the under-surface of A might be curved and concentric with the commutator surface. It is contemplated that A will carry a number of brush holders distributed along it, each of which holders will be adjusted laterally so as to stagger the brushes around the commutator in the desired manner. In such a case each holder may carry a single brush box or several boxes may be mounted on each holder.—*April 27th*, 1938.

SWITCHGEAR.

483,203. July 30th, 1937.—ELECTRIC LIQUID BLAST CIRCUIT INTERRUPTERS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

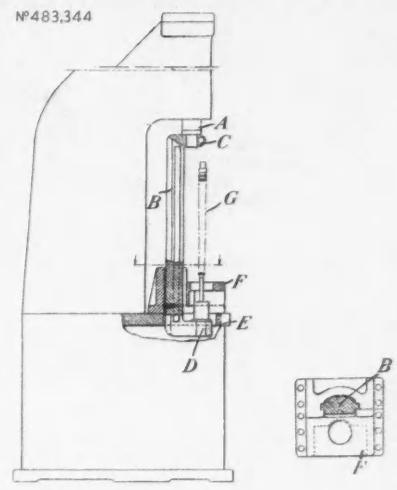
This invention relates to electric circuit interrupters, more particularly to high-tension circuit breakers of the explosion chamber type. The explosion pot is provided with tubes A of suitable insulating material, each extending through and being secured in the side walls of the explosion pot. The insulating tubes, each of which forms an exhaust passage from the interior of the explosion pot, are arranged so that the inner open ends are adjacent and along the arc path between the contacts B and C. To prevent combining of the conducting gas bubbles formed at the outer ends of these tubes, which could cause flash-over, the outer ends are separated by placing the tubes in an angular relationship with respect to each other. The four tubes, shown by way of example, are arranged in angular radial relationship with respect to the arc path, the upper and lower tubes having an angular relationship of approximately 90 deg. With this arrangement a comparatively large number of exhaust ports can be disposed closely adjacent to the main arc path throughout its length within the explosion pot. The individual insulating tubes which extend an appreciable distance from the side walls of the explosion pot towards the arc inherently provide a large voltage creepage surface between passages by reason of the tube surfaces which extend transversely across the arc.—*April 13th*, 1938.



MACHINE TOOLS AND SHOP APPLIANCES.

483,344. November 19th, 1936.—MACHINE TOOLS, Lapointe Machine Tool Company, Ltd., Edgware, Middlesex; *Oliver William Bonnafe*, 11, *Russell-street, Hudson, State of Massachusetts, United States of America.*

It has been found in vertical hydraulic broaching machines, for example, that where a broaching tool is pushed through a work piece from above, the pressure exerted is liable to fracture a tool which is of relatively great length. To avoid this and other disadvantages the present invention consists in an attachment capable of application to any machine tool wherein power is applied by pressure from above and comprises a slide having means for connecting it to the lower end of a tool to draw it downwards through or across the work piece. In the construction illustrated there is attached to the lower end of the piston A of a vertical hydraulic broaching machine a slide B having laterally extending brackets C and D at each end. A is concentrically above the aperture in a work table E upon which the work piece would normally be supported. Above and around the aperture in E is mounted a secondary work table F, which has an aperture over which the work piece is adapted to be mounted, and through a slot in which the slide B passes. The sides of the slot are recessed to engage the guide ribs formed on B. This secondary work table is shaped so as to extend parallel to

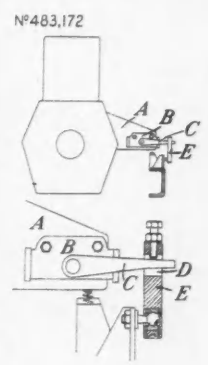


and above the platen E and is formed with lugs whereby it can be secured by means of bolts. The lower end of the broach G is secured in the bracket D by means of a detachable coupling device, whilst the upper end of the broach is free. With this arrangement the broach is pulled downwards through the work piece.—*April 19th*, 1938.

MOTOR CARS AND ROAD TRAFFIC.

483,172. February 22nd, 1937.—IMPROVEMENTS IN MOUNTING ENGINES, Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

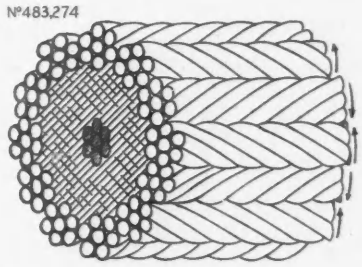
By this invention the small oscillatory movements of an engine mounted on a resilient suspension are not prevented until the movement reaches a predetermined amount, when a damper is brought into effect. Referring to the drawings, it will be seen that the arm A is fitted with a damping device, as, for example, a double-acting hydraulic oscillation damper B. The lever C of the damping device extends laterally, and is free to move up and down within narrow limits in an aperture D of a member supported intermediately between C and the vehicle frame. During free movements the damper does not come into operation and no appreciable forces are transmitted to the vehicle frame. Upon the occurrence of larger vibrational movements, the lever C will encounter a set screw in rising, and the member E in descending. The amount of free movement can be varied by adjusting the set screw. The arrest of the lever C brings into operation the damping device.—*April 13th*, 1938.



MISCELLANEOUS.

483,274. October 12th, 1936.—IMPROVEMENTS IN FLEXIBLE CABLES, Siemens Brothers and Co., Ltd., Caxton House, Tothill-street, Westminster, London, S.W.1, and Albert Henry Roberts, of 35, Eagles Field-road, Plumstead, London, S.E.18.

It is the object of the invention to reduce the deleterious effects on the wires or strands consequent upon the movement of the cable. The strands in a layer are even in number and each consists of a number of wires helically twisted together, adjacent strands in the layer having their component wires twisted in opposite directions but with the same length of twist,

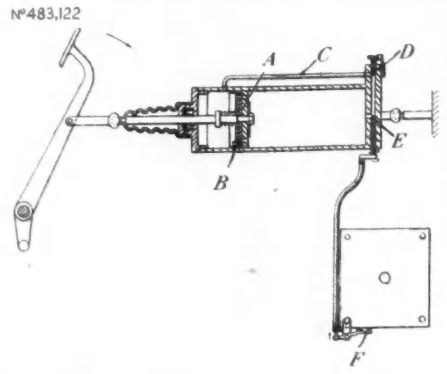


so that the wires of one strand tend to mesh with those of an adjacent strand. During twisting and bending of the cable there is a tendency to impart rotational movements to the strands and a rolling movement takes place rather than a grinding movement. The strands laid up in this manner may themselves form a conductor of an electric cable or they may provide a protective sheath round one or more conductors, insulated from the conductors. The drawing shows a cable in which the arrangement of the invention is employed as a sheath about a central conductor. In this case the sheath may be employed as a screen and protective cover which is earthed or may serve as the outer conductor of a concentric cable.—*April 12th*, 1938.

483,122. July 16th, 1937.—CLUTCH CONTROL MECHANISM, Eric Cookson, 3, Wilkinson-street, off South Park Drive, Blackpool.

This invention relates to a device for controlling the return movement of a clutch pedal as employed upon motor vehicles, and has for its object to provide a device which automatically takes care of the return movement of the pedal. When the clutch pedal is depressed the piston A is forced down the cylinder, liquid passing from one side of it to the other through holes. When the pedal is released its return, under the load of its spring, is prevented by a spring-loaded plate B covering the holes in A. The liquid at the rear of A is then allowed to

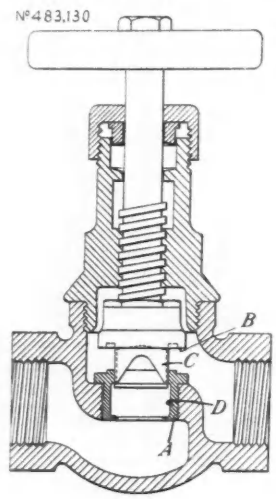
pass to the front of the cylinder through the by-pass pipe C and its rate of flow is controlled by the needle valve D. In this manner by the setting of the valve D the rate at which the clutch is re-engaged is controlled irrespective of the pedal movement. This controlled movement may, however, be too rapid for first and reverse gears, and to provide for this a further needle valve E is provided in the by-pass line between D and the front of the



cylinder. E is controlled by the movement of the selector rods of the first and reverse gears, which project beyond the gear-box case and actuate the lever F. The lever F is connected to E by a Bowden cable and when first or reverse gears are operated the valve E further closes and restricts the flow in the by-pass C to slow down the return movement of the clutch pedal.—*April 12th*, 1938.

483,130. September 13th, 1937.—VALVES FOR STEAM, James Edward Grainger and George William Craig, Craven House, 121, Kingsway, London, W.C.2.

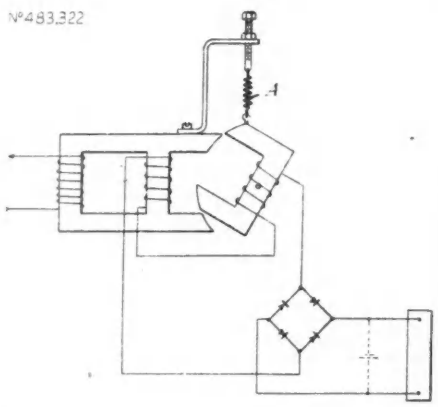
The object of the invention is to provide constructional improvements in valves for steam which will render them less liable to damage by grit or similar impurities in the steam or other fluid. The upper end of the sleeve A is provided with an annular seat adapted to co-operate with the annular face B of the valve member which has a hollow cylindrical extension C provided with ports of inverted V or similar shape. The inner wall of the sleeve A is cut away as shown to form an annular



cavity D extending over an area of the sleeve equal to at least half that of C when the valve is closed. Further, at its lower end the sleeve A is provided with a flange which reduces the diameter of the inlet to the valve so that any gritty matter which the incoming steam or other fluid contains is delivered to the centre of the hollow valve, and is thus able to pass through the ports. The provision of the cavity D over a considerable area of the sleeve and valve enables a tight fit to be maintained at the upper end of the guide and enables any gritty matter, which is admitted when the valve is closed, to accumulate and so to be carried through the valve port as soon as the valve is opened.—*April 12th*, 1938.

483,322. October 16th, 1936.—CONTROL CIRCUITS FOR ELECTRIC RECTIFIERS, *Westinghouse Brake and Signal Company, Ltd., of 82, York-road, King's Cross, London, N.*1.

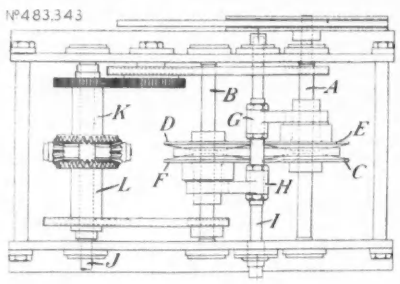
This invention relates to control circuits for electric rectifiers of the type in which the A.C. is fed to the rectifier from a transformer provided with a variable reluctance magnetic leakage



path for altering the proportion of the flux energising the secondary winding of the transformer. The object of the invention is automatically to control the voltage fed to the rectifier in such a way that the output of the rectifier is stabilised. The leakage path is constituted by a movable core member having an auxiliary winding so connected in the input circuit of the rectifier that the core member automatically assumes a position under the opposing action of the magnetic flux. A spring ensures that the voltage impressed upon the input terminals of the rectifier by the combined action of the secondary and auxiliary windings is dependent upon the supply circuit voltage and upon the resistance of the load circuit, so that the output of the rectifier is automatically stabilised.—*April 19th*, 1938.

483,343. November 14th, 1936.—VARIABLE-SPEED GEARS, E. N. Mason and Sons, Ltd., Arclight Works, Colchester, Essex; and Frank Alaric Soward, "Highclear," Frating, near Colchester, Essex.

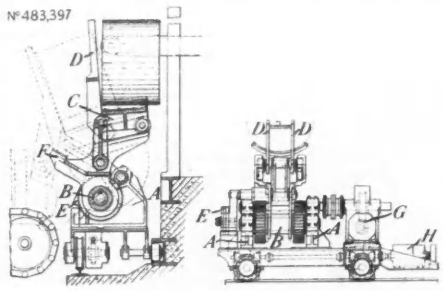
In a casing is mounted a driving shaft A and mounted parallel to the driving shaft is a second intermediate shaft B. To the shafts A and B are keyed the fixed members C and D of V pulleys, whilst the movable members E and F of these pulleys are carried by sleeves splined on to A and B. The fixed and sliding members form adjustable V pulleys which are engaged by a belt. By varying the spacing between the fixed members C D and the movable members E F the ratio of the speed between the driving and intermediate shafts can be varied. For the purpose of varying the position of E and F in unison the sleeves are engaged by forks and carried on bosses G and H, engaged by a screw-threaded spindle I mounted in the casing. In the casing there is mounted a third or driven shaft J driven



through the gearing as a whole for transmission purposes. On the transmission shaft J are mounted for free rotation two sleeves K and L, each of which carries a bevel sun wheel. With the sun wheels there engages a pair of planet pinions, rotatably mounted at opposite ends of a shaft passing transversely through J, which is suitably enlarged at this point. K is driven from the driving shaft A and the sleeve L is driven from the intermediate shaft B. These drives may be effected in any suitable manner. As shown in the figure, the sleeve K is driven by the driving shaft A through the medium of belt pulleys and toothed wheels. The sleeve L is driven by the intermediate shaft B through the medium of pulleys or chain wheels and a belt or chain. By means of the drives described the sleeves are rotated in opposite directions to one another. The drives from the driving and intermediate shafts to the sleeves may be of any suitable ratio. By means of this arrangement it is possible to obtain the following speed ranges:—A slow forward speed and a quick reverse speed or *vice versâ*; equal speeds forward and reverse; slow speed to fast speed.—*April 19th*, 1938.

483,397. December 10th, 1936.—COIL UNLOADERS FOR STRIP REELS, *United Engineering and Foundry Company, 2500 First National Bank Building, Pittsburgh, Pennsylvania, United States of America.*

In the reeling of metal strip at the end of a continuous hot strip mill it is desirable to remove each coil of strip from the reel as quickly as possible. In general, the unloaders comprise a counterbalanced tiltable support for receiving the coil as it is ejected from the reel and for carrying it in an arcuate path down to the conveyor, and means such as a dashpot operating in conjunction with the counterbalance for preventing the support from tilting away from the reel too rapidly under the weight of the coil. However, if the coil is large and heavy the dashpot and counterbalance do not offer sufficient resistance to the weight of the coil in preventing the support from tilting too rapidly and setting the coil down on the conveyor too heavily; while if the coil is relatively light its weight may not be sufficient



to tilt the support against the resistance of the counterbalance and the dashpot. The unloading device is mounted on a trolley running on rails at the end of the reeling machines, between them and the chain conveyor. A pair of spaced pedestals A A on the base carry a shaft B, on which is fixed a sliding cradle C for the reception of the completed coils of strip. Whilst a coil is being pushed off the mandrel by the stripper it engages the upright arms D D of the carriage and moves it backwards on the carriage supporting portion of the frame against the resistance of the counterweights E until its movement is arrested by the arm F. From this position the carriage and frame are tilted backwards as one unit, the movement being controlled by the motor G, which is geared to the shaft B through reduction and spur gears. The arms D D straddle and pass below the level of the conveyor so that the coil is deposited upon the moving belt. Power for moving the unloader along the tracks is supplied by the motor H geared to the traction wheels of the trolley.—*April 20th*, 1938.

483,358. May 18th, 1937.—ELECTRIC DISCHARGE DEVICES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

In the case of discharge vessels with liquid cathodes, such as mercury vapour rectifiers, considerably more vapour is developed by the cathode spot than is necessary for the discharge operation, with the result that a large quantity of the mercury sputters out of the cathode and the safe working of the discharge vessel is impaired. According to the invention, the discharge vessel, besides containing gallium which delivers the electrons, also contains mercury or an amalgam thereof which delivers vapour. These substances, under the operating conditions, neither mix together nor form any kind of compound. The element gallium is liquid at the relevant temperatures and at 1000 deg. Cent. shows a vapour pressure of only 3×10^{-9} mm. Hg. With the use of gallium as the cathode substance the mercury is particularly suitable as vapour delivering substance because gallium and mercury do not mix as liquids at any of the relevant temperatures nor do they form compounds together. It is therefore possible entirely to separate in the discharge vessel the function of the gallium delivering the electrons from that of the mercury delivering the vapour. The use of gallium, in the first place, affords the advantage that the vaporisation is very greatly reduced and the sputtering, especially with the fixing of the cathode spot, is very small. The danger of back ignition is greatly reduced.—*April 19th*, 1938.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY AND TO-MORROW.

INST. OF PETROLEUM TECHNOLOGISTS.—Conference on Oil Shale and Cannel Coal at Glasgow.

TO-DAY TO SUNDAY, JUNE 12TH.

INST. OF LOCOMOTIVE ENGINEERS.—Summer Meeting in Scotland.

SATURDAY, JUNE 11TH TO WEDNESDAY, JUNE 15TH.

INST. OF AUTOMOBILE ENGINEERS.—Summer Meeting at Buxton.

MONDAY, JUNE 13TH.

SOC. DES INGENIEURS CIVILS DE FRANCE: BRITISH SECTION. Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Methods of Coal Loading for Export Trade," R. F. Hindmarsh; "The British Grid System," J. Wright. 5.30 p.m.

TUESDAY, JUNE 14TH, TO FRIDAY, JUNE 17TH.

INST. OF BRITISH FOUNDRYMEN.—Annual Conference, at Bradford.

NEWCOMEN SOC.—Summer meeting in the Lake District.

WEDNESDAY, JUNE 15TH.

INST. OF CIVIL ENGINEERS.—Great George-street, Westminster, S.W.1. Conversazione. 7.45 p.m.

MONDAY, JUNE 20TH, TO WEDNESDAY, JUNE 22ND.

INST. OF HEATING AND VENTILATING ENGINEERS.—Summer meeting at Bournemouth.

TUESDAY, JUNE 21ST, TO FRIDAY, JUNE 24TH.

INTERNATIONAL ENGINEERING CONGRESS.—At Glasgow.

TUESDAY, JUNE 21ST, TO SATURDAY, JUNE 25TH.

BRITISH WATERWORKS ASSOC.—Twenty-seventh annual general meeting and conference at Plymouth.

TUESDAY, JUNE 21ST.

INST. OF CIVIL ENGINEERS: PORTSMOUTH, SOUTHAMPTON AND DISTRICT ASSOC.—Visit to the Winchester by-pass road works (County of Southampton).

WEDNESDAY, JUNE 22ND.

INST. OF ENGINEERS-IN-CHARGE.—Visit to Cadbury Bros., Ltd., Bournville works and village.

MONDAY, JULY 4TH, TO FRIDAY, JULY 8TH.

INST. OF ELECTRICAL ENGINEERS.—Summer Meeting at South Midland Centre.

WEDNESDAY, JULY 13TH, TO FRIDAY, JULY 15TH.

INST. OF MINING ENGINEERS.—Summer meeting at Manchester.

THURSDAY, AUG. 25TH, TO FRIDAY, SEPT. 2ND.

WORLD POWER CONFERENCE.—Vienna sectional meeting.

LAUNCHES AND TRIAL TRIPS.

HURRICANE, oil-engined tug; built by Henry Scott, Ltd., to the order of James W. Cook and Co., Ltd.; dimensions, length 75ft., breadth 20ft., depth 10ft. 6in. Engines, 600 B.H.P.; launch, May 30th.

BULOLO, motorship; built by Barclay Curle and Co., Ltd., to the order of Burns Philip and Co., Ltd.; dimensions, length 412ft. 6in., breadth 58ft., depth 30ft. 9in., gross tonnage 6500. Engines, two six-cylinder, single-acting, airless-injection, cylinders 620 mm. diameter by 1150 mm. stroke, constructed by John G. Kincaid and Co., Ltd.; launch, May 31st.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. A. G. GRAHAM has joined the staff of Asea Electric, Ltd., and will specialise on Century motors in the London area.

MR. H. E. TAUCHERT has been appointed managing director of Henry Pels and Co., Ltd., 32–38, Osnaburgh-street, London, N.W.1, in succession to the late Mr. Eugen Reinecke.

CATALOGUES.

VICTOR OIL ENGINES (COVENTRY), Ltd., Harefield-road, Coventry.—Particulars of the firm's series V high-speed lightweight oil engines.

CROFTS (ENGINEERS), Ltd., Thornbury, Bradford.—Folders on friction clutches, guards for shafting, &c., belt shifting gears, safety collars, &c.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C.2.—Bulletin No. 17, describing G.E.C.-Fraser and Chalmers steam and electric winding plant.

THOMAS FIRTH AND JOHN BROWN, Ltd., Sheffield.—Revised edition of the brochure the firm issues on its steels, describing their composition, treatment, and applications.

BROOKE TOOL MANUFACTURING COMPANY, Ltd., Warwick-road, Greet, Birmingham.—Particulars of spot facing cutters, high-speed steel counterbores, and machine vices.

BRITISH THERMOSTAT COMPANY, Ltd., Windmill-road, Sunbury-on-Thames.—A leaflet illustrating and describing a new range of automatic expansion valves for refrigeration plant.

GEORGE ELLISON, Ltd., Perry Barr, Birmingham, 20.—"The Ellison Handbook," which gives detailed information on ordering, installing, and maintaining all types of Ellison switchgear.

Printed on thin paper for overseas circulation.

The Engineer

LONDON, FRIDAY JUNE 17, 1938.

PUBLIC NOTICES.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Friday, 15th July, 1938, for the INSTALLATION of PUMPING EQUIPMENT at Bishopton R.O.F.

Drawings, specification, a copy of the conditions and form of contract, and forms for Tender, may be obtained from Room 65D, Third Floor, H.M. Office of Works, London, S.W.1, on payment of One Pound. (Cheques payable to the COMMISSIONERS, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. 4837

Air Ministry.

APPLICATIONS are INVITED for CIVILIAN POST of DRAUGHTSMEN, GRADE II, at various Royal Air Force Stations. Candidates should have had a good technical training, Engineering Workshop and Drawing Office experience.

Salary: Up to 82s. a week, depending on qualifications and experience. Promotion to Draughtsman, Grade I (£220-10-£260-12-£330 per annum), is governed by merit as and when vacancies arise.

Grade II appointments are non-pensionable. Draughtsmen, Grade I, and above are eligible for consideration for appointment to pensionable posts in the event of vacancies arising on the permanent establishment.

Application should be made on a form to be obtained (quoting reference No. B.505) from the UNDER SECRETARY OF STATE, Air Ministry, S.2.D. (S.205), Adastral House, Kingsway, W.C.2, to whom it should be returned. 4447

Applications are INVITED for the POST of CHIEF TECHNICAL INSTRUCTOR (Engineering and Building Construction) in the new Government Trade School, Haifa. Candidates, preferably not over 35, should possess suitable technical qualifications, good industrial experience and a minimum of 3 years' teaching experience in Technical or Trade Schools. Duties commence on 1st September, 1938.

The appointment is for 2 years in the first instance.

The salary is £445, rising by £15 a year to £550, together with an expatriation allowance of £50 a year, and free furnished quarters and board in return for residential duties.

Further particulars and forms of application can be obtained from the SECRETARY, I.P.R./CA, Board of Education, Whitehall, S.W.1. Candidates resident in Scotland should apply to the SECRETARY, Scottish Education Department, Whitehall, S.W.1. Closing date, Monday, 27th June, 1938. 4779

Crown Agents for the COLONIES.

COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POSTS :—

M/5731.—ASSISTANT ENGINEER REQUIRED for the Malayan Public Works Service for three years, with possible permanency. Salary 400 dollars a month, rising by annual increments of 25 dollars a month to 800 dollars a month. (The Government rate of exchange is now 2s. 4d. to the dollar.) A children's allowance is payable to married officers with children. Free passages, and, subject to certain conditions, for wife and family also. Liberal leave on full salary. Candidates, age 23-26, must be Corporate Members of the Institution of Civil Engineers, or hold an Engineering Degree recognised as granting exemption from Sections A and B of the A.M.I.C.E. Examination; but students of the Institution between the ages of 23 and 25 years, who have passed the A.M.I.C.E. Examination, are eligible for appointment. In either case, candidates should have had at least two years' practical experience on Engineering Works after taking their degrees or completing articles, at least one year of which should have been spent in a Drawing Office.

M/5947.—ENGINEER REQUIRED by the Government of Hong Kong for the Public Works Department for three years, with possible permanency. Salary £545 a year, rising to £950 a year. Residential allowance of £50 a year payable from the 4th to the 17th year of service, and thereafter of £100 a year. Free passages. Candidates, age 24-35, must be unmarried and be A.M.I.C.E. or A.R.I.B.A. or hold the Testamur of the Institution of Municipal and County Engineers or some other recognised Civil Engineering qualification. They must be well versed in all forms of Building Construction and Drainage, and have a thorough knowledge of Reinforced Concrete Work. Preference will be given to candidates who have had recent and up-to-date experience in a City or Municipal Engineer's Office.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting the reference number against the appointment for which application is made. 4866

Technical Assistants (unpensionable) to MECHANICAL ENGINEERS REQUIRED at Woolwich, Enfield, and Nottingham. Degree in Engineering or its equivalent is essential. Full particulars of workshop experience and positions held should be given. Must be British subjects, age not normally to exceed 35 years. Preference and age concession to ex-Service men. Salary £250-£367 (or in exceptional cases to £400) per annum, according to qualifications.

Application forms obtainable from the CHIEF SUPERINTENDENT of ORDNANCE FACTORIES, Advt. No. 221, Royal Arsenal, Woolwich, S.E.18, to be lodged in 10 days. 4836

War Department.

CIVILIAN ASSISTANT INSPECTORS REQUIRED by the Armaments Inspection Department, Royal Arsenal, Woolwich, for the Gun Ammunition and Carriages Divisions.

Candidates should preferably be not more than 45 years of age and possess an Engineering or Technical Degree or its equivalent. Experience of Manufacture is essential and experience of Inspection is desirable. If this experience relates to Gun Ammunition or similar type of Manufacture, it would be of further value.

Successful candidates may be posted to Woolwich or be required to Supervise Inspection in an area in the Provinces.

Salary £700 a year for fully qualified candidate.

The posts are not pensionable and have been approved for a limited period in the first instance. Ex-Service candidates given preference other things being equal.

Application forms, obtainable by postcard from the UNDER-SECRETARY OF STATE (C.5), The War Office, London, S.W.1, to be lodged not later than 27th June, 1938. Quote Appts./94. 4856

The Engineer

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The University of Sheffield.

ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

The Council are about to APPOINT an ASSISTANT LECTURER in MECHANICAL ENGINEERING. Salary £250 per annum. A somewhat higher initial salary might be paid to a man possessing exceptional qualifications. Further particulars may be obtained from the undersigned, with whom applications should be lodged by July 4th.

W. M. GIBBONS, Registrar.

4839

UNIVERSITY OF LONDON.

King's College.

FACULTY OF ENGINEERING.

CIVIL, MECHANICAL, ELECTRICAL and CHEMICAL ENGINEERING.

COMPLETE COURSES OF STUDY, extending over three years, are arranged for the Engineering Degrees of the University of London and/or for the Diploma and Certificate of the College.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING.
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C. H. LOBBAN, D.Sc., M. Inst. C.E.
Professor of Mechanical Engineering :—
S. J. DAVIES, D.Sc., Ph.D., Wh.Ex., M.I. Mech. E.
Reader in Mechanical Engineering :—
E. GIFFEN, M.Sc., Ph.D., A.M.I. Mech. E.

DEPARTMENT OF ELECTRICAL ENGINEERING.
Siemens Professor of Electrical Engineering :—
J. K. CATTERSON-SMITH, M.Eng., M.I.E.E.

DEPARTMENT OF CHEMICAL ENGINEERING
Head of Department :—
H. W. CREMER, M.Sc., F.I.C., M.I. Chem. E.

POST-GRADUATE COURSES and facilities for Research are provided in each of the above Departments, which are fully equipped with modern plant and apparatus.

There is a College Hostel and a large Athletic Ground.

For full information and prospectus apply to the SECRETARY, King's College, Strand, W.C.2. Tel., Temple Bar 5651. 4758

PUBLIC NOTICES.

Shrewsbury Technical College.

Principal: A. E. WHITE, B.A., B.Sc. (Lond.).

WANTED, to commence duties in September next, a FULL-TIME INSTRUCTOR in WOODWORK and BUILDING SUBJECTS for the Junior Day Technical and Evening Departments. Ability to assist with Drawing and Metal Work will be a recommendation; familiarity with modern woodworking machinery essential. Salary in accordance with the Burnham (Technical) Scale. Applications, stating age and giving particulars of education, training, qualifications and experience, together with copies of three recent testimonials, should be sent to the undersigned on or before Monday, 27th June.

W. H. PENDLEBURY, Clerk to the Governors.

County Buildings, Shrewsbury. 4814

Sudan Government.

The Director of Education invites APPLICATIONS for the POST of LECTURER in MECHANICAL ENGINEERING in the School of Engineering at Khartoum. Candidates should be between the ages of 24 and 28, unmarried, should have a University Degree in Mechanical Engineering, preferably of Honours standard, and have passed the Examination (or an examination qualifying for exemption) for Associate Membership of the Institution of Mechanical Engineers. Commencing salary £E.480 (or £E. 540, according to experience and qualifications), rising by biennial increments to a maximum of £E.1080 after eighteen years' service (£E.1 equals £1 0s. 6d.).

The selected candidate will not be required to take up his duties in Khartoum before 1st September, 1938.

Further particulars are obtainable from the UNIVERSITY APPOINTMENTS BOARDS, or from CONTROLLER, Sudan Government London Office, Wellington House, Buckingham-gate, S.W.1, to whom applications should be submitted not later than 1st July, 1938. Envelopes should be marked "Lecturer in Engineering." 4563

Crystal Palace School of ENGINEERING. Founded 1872.

MECHANICAL, ELECTRICAL AND CIVIL ENGINEERING SECTIONS.

Principal: F. C. P. LAWRENCE, M.S.E., Assoc. Inst. C.E., A.M.I. Struct. E.

Thorough up-to-date Practical and Theoretical Instruction. Course completed in two years.

Students admitted at beginning of any term. P1257

PUBLIC NOTICES.

London County Council.

REQUIRED in August, at School of Engineering and Navigation, Poplar, FULL-TIME ASSISTANT MASTER, with Extra First Class Board of Trade Certificate, for Department of Marine Engineering (courses for sea-going engineer officers in preparation for certificates of competency). Salary, Burnham Technical Scale (London). Forms from EDUCATION OFFICER (T.1), County Hall, S.E.1 (stamped addressed foolscap envelope), to be returned by 30th June. Canvassing disqualifies. 4847

Borough of Dover.

WATERWORKS RECONSTRUCTION SCHEME. CONTRACT NO. 4.

The Corporation invite TENDERS from specialist firms for the SUPPLY and ERECTION of a METERING, INDICATING, and RECORDING INSTALLATION, consisting of Three Venturi Tubes on the Outlet Pipes of Three Service Reservoirs and Three Reservoir Water Level Gauges, with all the Reading Instruments Centralised at the Waterworks Pumping Station, Connaught-road.

The general conditions of contract, specification, and form of Tender may be obtained from the undersigned for the deposit of Two Guineas (cheques to be made payable to the Borough Treasurer), which will be returned on receipt of a bona fide Tender.

Tenders, sealed and endorsed "Waterworks Reconstruction Scheme—Contract No. 4," are to be delivered to the Town Clerk, Brook House, Dover, not later than Twelve Noon on Tuesday, the 5th day of July, 1938.

The Corporation does not bind itself to accept the lowest or any Tender, or to defray any of the cost of its preparation.

WM. BOULTON SMITH, Borough Engineer.

Borough Engineer's Office, Maison Dieu House, Dover, 13th June, 1938. 4838

Chanctonbury Rural District COUNCIL.

DEEPENING OF BORE-HOLE NO. 1 AT STORRINGTON.

The above Council invite TENDERS from experienced Bore-hole Contractors for the DEEPENING of an existing 12in. Diameter BORE-HOLE at the existing Pumping Station near Storrington, about 1 mile south-west of St. Mary's Church.

Copies of the general conditions of contract, specification, bill of quantities, and form of Tender, prepared by the Council's Consulting Engineers, Edward Sandeman and Partners, of 15, Victoria-street, Westminster, S.W.1, may be obtained from the undersigned upon payment of a deposit of Two Guineas, which amount will be refunded upon receipt of a bona fide Tender and the return of the above-mentioned documents.

The successful tenderers will be required to enter into a guarantee bond.

Sealed Tenders, endorsed "Tender for Deepening No. 1 Bore-hole at Storrington," are to be delivered to the undersigned by Twelve Noon on Tuesday, the 21st June, 1938.

The Council do not bind themselves to accept the lowest or any Tender.

(Signed) PERCY AYLING, Clerk to the Council.

Council Offices, Storrington, Pulborough, 8th June, 1938. 4816

Essex County Council.

AVELEY SHIP LANE COUNCIL SENIOR SCHOOL.

CENTRAL HEATING AND DOMESTIC HOT WATER INSTALLATIONS.

The Education Committee is prepared to receive TENDERS for CENTRAL HEATING and DOMESTIC HOT WATER INSTALLATIONS at Aveley Ship Lane Council Senior School, now in course of erection.

Applications for specification and schedule of quantities, which may be obtained from the County Architect, must be received not later than Wednesday, the 22nd June, 1938.

A deposit of £1 1s., which will be returned only upon receipt of a bona fide Tender, should be forwarded to H. W. Collis, F.I.M.T.A., County Accountant, County Hall, Chelmsford.

Tender, securely sealed with wax, on the form and in the envelope provided, must be delivered to the undersigned not later than first post on Saturday, the 2nd July, 1938. No name or other distinguishing matter or mark indicating the identity of the sender must on any account be put on the envelope.

The Committee does not bind itself to accept the lowest or any Tender.

J. STUART, F.R.I.B.A., County Architect.

County Hall, Chelmsford, June, 1938. 4858

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CLASSIFIED ADVERTISEMENTS CLOSE FOR

PRESS — 2 P.M. WEDNESDAYS

The Engineer

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Entered as second-class matter at the Post Office, New York, N.Y., December 12th, 1896, under the Act of March 3rd, 1879 (Section 397, P.L. & R.).

*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next due, June 24th.

ADVERTISEMENTS.

The charges for Classified Advertisements is 1/- per line up to one inch—minimum chage 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

Postal Address, 28, Essex-street, Strand, London, W.C.2. Teleg. Address, "Engineer Newspaper, Estrand, London." Tel., Central 6565 (10 lines).

PUBLIC NOTICES.

City of Nottingham.

The Mental Hospital Visiting Committee invite APPLICATIONS from Firms desirous of TENDERING for HOT WATER SERVICE WORKS required for the Mapperley Hospital, Nottingham.

Drawings and specifications, prepared by the Consulting Engineers, Messrs. E. G. Phillips, Son and Norfolk, Arskus House, Annesley Grove, Nottingham, together with form of Tender and terms of contract, will be supplied to selected applicants upon application being made to the Consulting Engineers. Applicants should refer to contracts recently completed where work of a similar character has been carried out.

Tenders should be addressed to me, the undersigned, to arrive at this address not later than 6 p.m. on Monday, 4th July, 1938.

J. E. RICHARDS,
Town Clerk.

Guildhall, Nottingham,
9th June, 1938. 4813

County of Dorset.

NEW SENIOR SCHOOL, SHAFTESBURY, DORSET.

TENDERS are INVITED for the INSTALLATION of a LOW-PRESSURE HEATING SYSTEM and HOT WATER SUPPLY to the New Senior School, Shaftesbury, Dorset.

Application for particulars should be made to the County Architect, "Holly Bank," Acland-road, Dorchester, on or before the 27th June, 1938, accompanied by a deposit of TWO GUINEAS, which will be returned provided the applicant shall have sent in, and not withdrawn, a bona fide Tender. Cheques to be made payable to the Dorset County Council, and crossed "Lloyds Bank, Ltd."

Sealed Tenders, in envelopes provided for the purpose, must be received by me not later than 10 a.m. on Monday, 18th July, 1938.

The County Council will not necessarily accept the lowest or any Tender.

C. P. BRUTTON,
Clerk of the County Council.

County Offices,
Dorchester,
14th June, 1938. 4865

Galway County Council.

SWING BRIDGES OVER THE EGLINTON CANAL, GALWAY.

The Galway County Council invites TENDERS from competent Contractors experienced in Steel Work for the RECONSTRUCTION of TWO SWING BRIDGES in accordance with the plans and specifications prepared by the Council's Consulting Engineer, Mr. Nicholas O'Dwyer, B.E., M. Inst. C.E.I., Veritas House, Lower Abbey-street, Dublin.

The works will comprise the demolition of the existing bridges and the erection of two single-leaf swing bridges of overall lengths of 59ft. 9in. and 61ft. 9in. respectively by 29ft. in each case and other works ancillary thereto.

Copies of the drawings, specifications, general conditions of contract, bills of quantities, and forms of Tender may be obtained from the Consulting Engineer or from M. J. Keunedy, Esq., B.E., M. Inst. C.E.I., County Surveyor, at the County Buildings, Galway, on payment of a deposit of £5 5s., which will be returnable on receipt of a bona fide Tender not subsequently withdrawn.

Tenders, on the forms provided, enclosed in sealed envelopes, endorsed "Tender for Galway Swing Bridges," and accompanied by the schedule of quantities, priced and extended in ink, should be delivered to the undersigned not later than 4 p.m. o'clock on the eighth day of July, 1938.

The acceptance of any Tender will be subject to the sanction of the Minister for Local Government and Public Health, and the Council does not bind itself to accept the lowest or any Tender.

C. I. O'FLYNN,
County Secretary.

County Council Offices,
County Buildings, Galway.
Date, 7th June, 1938. 4815

Metropolitan Water Board.

TENDERS FOR THE SUPPLY OF STORES, &c.

The Metropolitan Water Board invite TENDERS for the SUPPLY of the undermentioned STORES, &c., for the period of 12 months commencing 1st August, 1938:—

Contract No.
2 .. Brushes, Brooms, and Handles.
5 .. Cotton Waste, Wipers, Hemp, Rope, &c.
10 .. Lead Pipe, Solder.
13 .. Oilman's Sundries.
14 .. Packings, Rubber Goods, Hose, and Belting.
15 .. Paints, Varnishes, Linseed Oil, Turpentine, &c.
24 .. Electric Lamps.

Tenders must be submitted on the official forms, which may be obtained from the Chief Engineer by personal application at the Offices of the Board (Room 171), or upon forwarding a stamped, addressed envelope (large).

Applicants should refer to the number of the Tender for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board," and endorsed in the manner indicated in the form of Tender, must be delivered at the Offices of the Board (Room 122), not later than 12 o'clock Noon on Monday, 27th June, 1938.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board:
173, Rosebery-avenue, E.C.1.
3rd June, 1938. 4782

Trowbridge, Melksham and

DISTRICT WATER BOARD.

TENDERS are INVITED for SUPPLYING and INSTALLING at the Works at Upton Scudamore of a 40,000 Gallons per Hour ELECTRICALLY DRIVEN BORE-HOLE PUMP.

Full particulars may be obtained from the Board's Engineer, Mr. W. Shaw, 22, Silver-street, Trowbridge.

Tenders, in plain envelopes, endorsed "Pump," to be delivered to the undersigned not later than Noon on Friday, the 1st day of July, 1938.

The lowest or any Tender will not necessarily be accepted.

By Order,
J. H. ANDERSON,
Clerk of the Board.

Silver-street, Trowbridge,
June 9th, 1938. 4812

Government of the Punjab,

INDIA.

APPLICATIONS are INVITED for TWO APPOINTMENTS of ASSISTANT EXECUTIVE ENGINEER in the Public Works Department (Irrigation Branch) of the Government of the Punjab.

Candidates must be European British subjects of non-Asiatic domicile and aged not less than 21 nor more than 24 years on the 1st August, 1938. They must possess a degree of a recognised University or other approved qualifications, details of which may be obtained from the High Commissioner for India. Applications will also be accepted from candidates entered for one of the prescribed degrees or other qualifications who expect to receive the qualification during the current year.

The appointments are permanent, subject to two years' probation, and pensionable. Initial pay Rs. 300 a calendar month plus overseas pay of Rs. 150 a calendar month, rising by annual increments of Rs. 25 a calendar month to Rs. 700 a calendar month plus overseas pay of £30 a calendar month (Rupee equals 1s. 6d. approx.). Prospects of promotion to highest posts in the service. Free first-class passage to India and, if confirmed after probation, further passages for purposes of leave.

Further particulars and forms of application may be obtained, on application by postcard, from the HIGH COMMISSIONER FOR INDIA, General Department, India House, Aldwych, London, W.C.2. Last date for receipt of applications, 8th July, 1938. 4846

PUBLIC NOTICES.

City of Durban.

APPOINTMENT OF DEPUTY CITY AND WATER ENGINEER.

APPLICATIONS are INVITED for the POSITION of DEPUTY CITY and WATER ENGINEER for the City of Durban, Natal, South Africa. The grade for the position is £1500-£37 10s.-£1736-E, subject to the Council's Scheme of Deflation of Salaries and Wages. The appointment will be in terms of the Council's General Conditions of Service and Leave Regulations, and the commencing salary will be at the minimum of the grade.

Applicants must be under the age of 45 years.

The applicant must be a Corporate Member of the Institution of Civil Engineers, or possess a Degree in Civil Engineering.

The Departmental activities coming under the control of the City and Water Engineer at present include:—

PUBLIC WORKS, embracing Roads, Reinforced Concrete and Structural Steel Construction, Storm Water Drainage, Sewerage, Housing, Surveys, Town Planning, Beach Restoration, and General Development.

PARKS AND GARDENS, entailing Lay-out and Control of all Parks, Gardens, and Open Spaces.

BEACH MANAGEMENT, which includes Control of Bathing and General Pleasure Amenities.

STREET CLEANING AND CONSERVANCY, the executive side of Public Health Arrangements dealing with Street Cleaning, Night Soil and Rubbish Removals and Cemeteries.

WATERWORKS, including the Administration of all Works and Estates pertaining to Water Supply.

The successful applicant will be required to undergo a medical examination by a nominee of the Council.

Applications, stating age, qualifications and experience in full, and accompanied by COPIES of not more than three testimonials and supporting documentary evidence of qualifications and satisfactory state of health, must reach the office of the Town Clerk, Durban, South Africa, not later than Friday, 15th July, 1938.

Personal canvassing for the appointment is prohibited and proof thereof will disqualify a candidate, vide Council's Standing Order No. 1.

E. B. SCOTT,
Town Clerk.

Town Clerk's Office,
Municipal Buildings,
Durban,
11th May, 1938. 4650

County Borough of Tynemouth.

WATER DEPARTMENT.

APPLICATIONS are INVITED for the APPOINTMENT of ENGINEERING ASSISTANT at a commencing salary of £350 per annum, increasing by annual increments of £25 to £400, subject to satisfactory service.

Candidates must be Associate Members of the Institution of Civil Engineers or have passed part of their examinations, and have experience in the Design, Calculations, and Details for Reinforced Concrete Work for Large Service Reservoirs.

The position is designated under the Local Government and Other Officers' Superannuation Act, 1922, and the selected candidate will be required to pass a medical examination.

Applications, stating age, experience, and qualifications, accompanied by copies of three recent testimonials, must be delivered to the undersigned not later than 10 a.m. on the 28th June, 1938.

Canvassing, directly or indirectly, will be disqualified.

Dated this 14th day of June, 1938.

FRED G. EGNER,
Town Clerk.

14, Northumberland-square,
North Shields. 4859

Civil Engineer on Temporary

Contract REQUIRED for service with the Sudan Irrigation Department.

Candidates must be between 25 and 27 years of age on 1st September, 1938, and must have passed by that date the A.M.I.C.E. Examinations, Parts A and B, or the exempting examination of a British University.

The appointment would be for a definite period of two years with a salary of £E.630 per annum for that period (£E.1 equals £1 0s. 6d.). The tour of service would cover about twenty months, after which a period of four months' leave on full pay would be granted.

Free passage on appointment. Strict medical examination.

Candidates should apply on a form to be obtained from the CONTROLLER, Sudan Government London Office, Wellington House, Buckingham-gate, London, S.W.1, marking envelope "Engineer." 4857

States of Guernsey Water-

WORKS DEPARTMENT.

APPOINTMENT OF ASSISTANT ENGINEER.

APPLICATIONS are INVITED for the POSITION of ASSISTANT ENGINEER at a commencing salary of £300 p.a., rising, subject to satisfactory service, to £350 p.a. by four annual increments of £12 10s.

Preference will be given to Corporate Members of the Inst. of Civil Engineers, and applicants should have had experience in the Design, Construction, and Management of Waterworks Pumping and Purification Plant.

Applications, stating age, experience, and qualifications, and accompanied by copies of not more than three testimonials, to be delivered to the undersigned before Noon on Saturday, July 2nd, 1938.

WALTER H. MORGAN, B.Sc., A.M.I.C.E.,
Engineer and Manager.

The Water Office,
Guernsey. 4829

SITUATIONS OPEN.

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

WANTED, ASSISTANT SUPERINTENDENT, to Supervise the Manufacture of Railway, Tramway, and other Types of Traction Motors. Must have had previous executive experience in all departments of works manufacture and production.—Address, 4842, The Engineer Office. 4842 A

WANTED, ASSISTANT to GENERAL MANAGER, to Specialise on Works Side. One having technical training and having served an apprenticeship in works. Age 25-30.—Address, 4826, The Engineer Office. 4826 A

WANTED for Manchester District, Reliable DRAUGHTSMEN, accustomed to Internal Combustion Engine Design, preferably Marine Engines.—Address, stating age, experience, and salary required, 4861, The Engineer Office. 4861 A

WANTED, REPRESENTATIVE in England for Land Boiler Work.—Address, 4823, The Engineer Office. 4823 A

APPLICATIONS are INVITED for the POST of LEADING ASSISTANT in the Bridge Office of a Railway Engineer in London. Candidates should be between the ages of 35 and 42 years, and have had experience in Steelworks, as well as on the Design and Construction of Bridgework in Great Britain or Ireland. They should also be Corporate Members of the Institution of Civil Engineers.

The commencing salary will be £500 per annum, and there are prospects of advancement for a suitable man.

Address, giving full particulars of experience, 4860, The Engineer Office. 4860 A

SITUATIONS OPEN.

ASSISTANT MECHANICAL ENGINEERS REQUIRED for service in the East. Age not to exceed 25 years. Workshop training and good technical qualifications essential.—Address, 4820, The Engineer Office. 4820 A

ASSISTANT ENGINEERS REQUIRED by Large Oil Company for service in Far East and elsewhere. Age 22 to 28, unmarried. University Degree or equivalent qualification and some practical experience in Mechanical Engineering Works essential. Salary from £450 per annum.—Write, Box "T.Z.M.," c/o 95, Bishopsgate, London, E.C.2. 8877 A

DESIGNER REQUIRED, Provinces. Heating, Ventilating, and Air Conditioning. Only first-class men with up-to-date ideas and able to work without supervision need apply. State experience, age, and salary required.—Address, 4821, The Engineer Office. 4821 A

ENGINEER REQUIRED for Midland Firm of Pump Manufacturers for demonstration and service. must have good knowledge of Centrifugal Pumps. Excellent opportunity for the right man. Write fully in first instance, stating age, experience, and salary required.—Address, 4825, The Engineer Office. 4825 A

ENGINEER WANTED for Important Staff Position, with prospects, for Engineering Works in Manchester district. Must have good technical education and good general experience. Should have good knowledge of Shop Practice. Must have initiative and inventive ability and ability to organise and control. State full details of experience, age, and salary expected.—Address, 4828, The Engineer Office. 4828 A

EXPERIENCED MECHANICAL and ELECTRICAL ENGINEER, as Assistant to Supdt. Engineer, for service in the East. Age about 30 years, A.M.I. Mech. E. or A.M.I.E.E., with sound practical and technical training. Practical experience of either Rice Milling, Saw Milling, or Cotton Ginning an advantage. —Address, 4819, The Engineer Office. 4819 A

LARGE CRANE FIRM in the North of England REQUIRE a TECHNICAL SALESMAN for their MAIN OFFICE to FOLLOW UP INQUIRIES and ADVISE CLIENTS. Must have previous experience in the CRANE TRADE.

Progressive position for suitable applicant.

Address, giving full details of experience, age, and salary required, 4863, The Engineer Office. 4863 A

MARINE ASSISTANT WANTED for Supervision of Shipping Accommodation for Vessels of all sizes on the Thames. Navigation experience essential, and some training in Civil Engineering on Marine Works desirable; must be willing to undertake Diving. Age about 35.—Address, giving full particulars of experience and salary required, 4803, The Engineer Office. No original testimonials. 4803 A

MECHANICAL ENGINEER.—Large London Organisation has VACANCY offering excellent opportunities for ENGINEER, aged 28-35, with first-class technical qualifications and preferably Marine Experience. Extra Chief's Certificate preferred but not essential.—Address, giving full particulars of apprenticeship, practical experience, age, and educational certificates, P1360, The Engineer Office. P1360 A

PLANNING ENGINEER.

REQUIRED, for an established Aircraft Factory, a MAN capable of Planning Production Work and Supervising Staff. It is not necessary for a candidate to have had aircraft experience, although this would be an advantage, but it is essential he should be able to understand complicated lay-outs and criticise them from a production point of view.

A wide knowledge of production methods and experience in administrative work is essential.

Age not to exceed 40. Applicants are requested to state salary required and experience.

Address, 4844, The Engineer Office. 4844 A

REFRIGERATION ENGINEERS REQUIRE IMMEDIATELY a CHIEF DESIGNER or TECHNICAL HEAD to Take Charge of Design, Specification, and Performance of Large Marine and Land Installations. Only first-class men with reputation based on achievement should apply for this post. State fullest details of experience, age, and salary required, and when at liberty, in the strictest confidence.—Address, 4841, The Engineer Office. 4841 A

REQUIRED AT ONCE, REPRESENTATIVE having good connection with Engineering Trade, and able to introduce Contract Work for up-to-date Engineering Firm in Midlands.—Address, with full details, &c. 4854, The Engineer Office. 4854 A

REINFORCED CONCRETE DESIGNER REQUIRED by leading Westminster Firm of Civil Engineering Contractors.

Address, stating age, qualifications, with copies of testimonials, and salary required, 4834, The Engineer Office. 4834 A

SALES MANAGER.—APPLICATIONS for the POST of SALES MANAGER are INVITED by a Firm of Steel Makers producing Plates, Sheets, Sections, and Special Steels.—Address replies, which will be treated in confidence, should state full experience, qualifications, age, and salary desired, 4824, The Engineer Office. 4824 A

SALES ENGINEER REQUIRED for Well-known Steam Trap Manufacturer. Technical competence essential. Full particulars of experience, age, &c.—Address, 4818, The Engineer Office. 4818 A

THE Post You are Seeking May Not be Advertised in this Column, but do not Lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

TWO THOROUGHLY COMPETENT SURVEYORS REQUIRED by important Firm of London Engineering and Building Contractors for permanent (pensionable) positions, for service in the first instance—in South Wales. Applicants should be expert Measurers and Adjusters for both or either Building and/or Engineering Works. Good salaries are available to the right men. Applicants should give full particulars of age, past experience, qualifications, if any, and any recent references and salary required, and date when free to commence.—Write Box 1669, L.P.E., 110, St. Martin's-lane, London, W.C.2. 4764 A

WANTED, Experienced LEADING DRAUGHTSMAN, up-to-date knowledge Hydraulic and General Engineering essential; permanent situation for suitable man. Only those with first-class designing experience need apply. State age, experience, salary, &c., to HENRY BERRY and CO., Ltd., Croydon Works, Hunslet, Leeds, 10. 4840 A

DRAUGHTSMAN WANTED, Experienced in Railway Carriage and Wagon Work.—Address, giving full particulars of experience and wages required, 4864, The Engineer Office. 4864 A

DRAUGHTSMAN WANTED for Power Station Extensions. Applicants must be quick, accurate and reliable, have had special experience in designing heavy Structural Steel Work and be able to take out quantities.—Address, stating age, technical training, experience, and giving salary expected, 4851, The Engineer Office. 4851 A

DRAUGHTSMAN (25/30), for London. Experience Design Mechanical Engineering Parts.—Address, P1361, The Engineer Office. P1361 A

For continuation of Small Advertisements see page 4.

Pencil Portrait No. 17

SIR LEONARD PEARCE, C.B.E.

DRAWN FOR THE ENGINEER BY ELLIOTT & FRY

A Seven-Day Journal.

Birthday Honours.

IN the official list of Birthday Honours bestowed by the King, the following names appear:—Lord Stonehaven, President of the Institution of Naval Architects, becomes a Viscount in recognition of his political and public services, and Lord Weir receives a like honour, for his public services. Sir Josiah Stamp, President of the London, Midland and Scottish Railway Company, becomes a Baron, in recognition of his public services, and a Baronetcy is conferred upon Sir William Prescott, Chairman of the Metropolitan Water Board. Among the Knights Bachelor appear the names of Mr. Andrew Agnew, the managing director of the Shell Transport and Trading Company, Ltd., and Mr. Arthur Jackson, managing director of Sir John Jackson (Singapore), Ltd. Sir Arthur Stanley Eddington receives the Order of Merit. In the Order of the Bath, Engineer Rear-Admiral H. H. Perring is made C.B. in the Military Division, and Sir Cyril Hurcomb, Chairman of the Electricity Commission, becomes K.C.B. in the Civil Division. In the Dominion Services List, Mr. John Wood, Under-Secretary and Engineer-in-Chief of the Public Works Department of the Dominion of New Zealand, is made C.M.G., and Professor T. H. Easterfield, former Director of the Cawthorn Institute of Scientific Research, Nelson, in the Dominion of New Zealand, becomes a K.B.E.; while Mr. H. P. Brown, Director-General of Posts and Telegraphs in the Commonwealth of Australia, receives a Knighthood. In the Colonial Office List Mr. J. W. Spiller, Chief Engineer, Designs Branch, Crown Agents for the Colonies, is made a C.M.G., and Mr. K. C. Strahan, Chief Mechanical Engineer, Kenya and Uganda Railways and Harbours, becomes C.B.E. in the Civil Division. In the Order of the British Empire, Colonel R. B. Pitt becomes C.B.E. in the Military Division, and in the India Office List, Mr. J. D. H. Bedford, Indian Service of Engineers and Chief Engineer and Secretary to the Government of the Punjab, in the Public Works Department, becomes C.S.I.

Aircraft from America.

ON Thursday, June 9th, the Air Ministry announced that the Government had given consideration to the report of the Air Mission which recently visited the United States of America and Canada. The Mission was instructed to inquire primarily into the possibility of purchases for early delivery of aircraft having certain special characteristics. A considerable number of proposals were made, not all of which fulfilled the conditions above referred to, and eventually the Mission recommended that negotiations should be entered into with two American firms for a total of 400 aircraft. The Government accepted this recommendation, and contracts have now been negotiated for 200 aircraft suitable for general reconnaissance duties, and 200 aircraft suitable for advanced training duties. The Mission also pursued certain discussions with firms in Canada as to the possibility of bringing into being increased capacity in that country for the manufacture of aircraft on a long-range plan. The Government has under consideration certain tentative proposals which have been formulated as a result of these discussions.

Building Research.

THE report of the Building Research Board for the year 1937, which has just been published by the Department of Scientific and Industrial Research, lays special stress on the importance of the developments which have recently taken place in the subject of soil mechanics. The soil mechanics section of the Building Research Station has been strengthened, but is still, it is felt, on a too modest scale. The hope is expressed that support may be forthcoming from outside bodies interested in this work which will enable the present programme to be expanded to a considerable extent in order that both fundamental research and research directed to the solution of problems of immediate practical interest may be accelerated. Work has been carried out on the settlement of structures and observations on buildings have been made. The question of the failure of earth banks has been studied on a practical scale. The report points out that the stability of an earth slope depends on the shear characteristics of the soil in the slope, and in the foundation layers, and that the influence of bad weather conditions must also be taken into account. Experience shows that slides in clay slopes take place along surfaces which have a conspicuous curvature approximating to a cylindrical form. Methods are described in the report which have been developed for an analysis of the stability of slopes on the basis of the equilibrium of a segment of such a cylindrical surface. Other subjects dealt with in the report include the cleaning of stone buildings, upon which much important work has been done, including the effect of frost on building stones, the correlation of elastic properties and weathering quality, and the section of Portland stone for sculpture and carving. The prevention of cracking in rendered finishes has been closely studied, both in Britain and on the Continent, and full-scale tests have been carried out. Other sections of the report deal with such varied subjects as wind pressures, efficiency of heating systems, glass bricks, accoustical properties of domestic buildings, smoky chimneys, and dry masonry.

New Aircraft Orders for Great Britain.

ON Saturday, June 11th, it was stated by the Air Ministry that one of the largest orders for aeroplanes ever placed with a British firm will shortly be awarded to Phillips and Powis Aircraft, Ltd., of Reading. The order will be for high-speed training machines equipped with Kestrel engines, and they will be, it is stated, among the world's fastest aeroplanes. The order, it is understood, exceeds that recently given for 200 American training machines, and delivery is to be made within the next year or two. The Air Ministry also stated that during the last few weeks orders for a large number of Airspeed Oxford monoplanes has been placed, and that these machines will be utilised for training purposes. These orders also amount to several times the American order. The original order was placed with Airspeed, Ltd., of Portsmouth, the designers, and in the last few weeks substantial orders for the same planes have also been given to the De Havilland Aircraft Company, of Hatfield, and the Percival Aircraft Company, of Luton, as well as additional orders to Airspeed, Ltd. These recent orders are to be completed within about two years. Phillips and Powis Aircraft, Ltd., has also received recently substantial orders for Magister single-engined trainers. Further to our Journal note of last week with regard to the proposed new factory for Rolls-Royce aircraft engines at Crewe, the Air Ministry announces that the Air Council has decided to proceed with this factory. As in the case of the similar factories already established in connection with the expansion scheme, the factory will be financed and owned by the Government, but its management will be entrusted to Rolls-Royce, Ltd.

The Astronomer Royal's Report.

THE report of the Astronomer Royal, Dr. H. Spencer Jones, to the Board of Visitors of the Royal Observatory, Greenwich, which was read at the recent Annual Visitation, states that the sunspot frequency during the past twelve months had not been exceeded since the maximum of 1870. During the year there were about thirty-five groups whose maximum area exceeded 500 millionths of the sun's hemisphere. Of these, fourteen groups attained or exceeded 1000 millionths in area, and three groups reached an area of 3000 millionths. At the request of the Engineer-in-Chief of the General Post Office, and the Superintendent of the Radio Research Station at Slough, advance notification of the appearance of sunspots is being given to the General Post Office and the Research Station as indicating the probable occurrence of terrestrial magnetic storms. In connection with the total eclipse of the sun on October 1st, 1940, an expedition is to be sent to Africa, and it is planned to study the Einstein displacement with an equatorial camera designed to shift very rapidly from the eclipse field to a check field and back several times during totality. The position with regard to the repair by the trade of the high-grade instruments necessary for navigational use is, the report states, still unsatisfactory. The public demand for high-grade watches is now very small, and this has led to the almost entire elimination of highly skilled craftsmen, not only in the adjusting but in other branches of the repairing trade. The present position is such that the illness of one key craftsman can seriously hamper all the firms undertaking Admiralty repairs. The Observatory has now its own adjusting and repair shop, which has greatly facilitated and accelerated the repair of the watches. The interference with observations at low altitudes caused by the installation of mercury vapour discharge lamps by the Greenwich Borough Council in certain streets near the Observatory has been improved by the installation of a system of high-pressure gas lighting, with lamps having a horizontal cut-off. The work of the magnetic station at Abinger is being disturbed by the artificial magnetic fields caused by the electric trains on the Guildford and the Holmwood to Portsmouth lines.

Renewal of the Steel Cartel.

EXPECTATIONS that the European Steel Cartel would be renewed at the meeting in Paris on June 14th have been realised. This was officially announced after a meeting of the Joint Co-ordinating Committee of the Cartel at which representatives of the American steel-exporting companies were present. The internal difficulties of the Belgian group arising from the attitude of the firm of Gustave Böel, of La Louviere, which demanded an increase in its export quota or an indemnity, had been settled by the intervention of the Belgian Prime Minister. As a result, it has been found possible to renew all the comptoirs until December 31st, 1940, and at the same time the agreement which was entered into between the British and Continental steel makers in 1935 has been similarly extended. The official statement also refers to negotiations which have been taking place during the past month between the Cartel and the American steel-exporting companies and indicates the probability of an effective agreement being confirmed at an early date. On the question of prices it is announced that all groups agreed unanimously to stabilise their quotations at the existing levels. The delay in reaching agreement for the renewal of the Cartel is believed to have been one of the principal causes of the decline in the volume of export business. Overseas buyers were aware that had it been found impossible to extend the Cartel practically all international arrangements would have been affected and the agreement between the British Iron and Steel Federation and the European Steel Cartel would have collapsed.

Imperial Airways, Ltd.

SPEAKING in the House of Commons on Tuesday, June 14th, the Air Minister, Sir Kingsley Wood, announced that with the full concurrence of the Government the board of Imperial Airways, Ltd., had invited Sir John Reith, the Director-General of the British Broadcasting Corporation, to become the whole-time chairman of Imperial Airways, a position which Sir John had accepted. The Minister also said that Sir James Price, who, until recently, was the Deputy Secretary of the Ministry of Labour, had also joined the board, and his appointment would enable the company to draw on his wide experience of labour and staff questions. Mr. Woods Humphrey, the present managing director, has resigned from the board, but he has offered to make available his knowledge and experience to the new chairman. The board has placed on record its high appreciation of the services of Mr. Woods Humphrey. Sir Kingsley Wood also said the board had asked the new chairman to investigate the charges made against the management of the company, and when those inquiries had been made it proposed to make a public statement on the matter. Sir John Reith enters on his new appointment with a training as an engineer and a wide experience of organisation on a large scale. He is forty-nine years of age and was educated at the Glasgow Academy and Gresham's School, Holt, and the Royal Technical College, Glasgow. He served a five years' apprenticeship to an engineering firm, and was for some time with S. Pearson and Son, of London. During the war he saw service with the R.E. in France, and on the staff of the Engineer-in-Chief at the Admiralty, and also in America. Before joining the British Broadcasting Company, Ltd., as its general manager in 1922, he was for some time general manager at the Coatbridge Works of Wm. Beardmore and Co., Ltd.

The "Courtier" Flying-Boat Accident.

THE Air Ministry has now published an abstract of a report which it has received from the Greek Government on the accident which occurred to the Imperial Airways flying-boat "Courtier" G–ADVC, which, it may be recalled, met with mishap during its landing from Alexandria in the Phaleron Airport, Athens, on October 1st, 1937. During landing the boat failed to flatten out and crashed into the sea at comparatively high speed at an angle slightly less than the original angle of descent. The bottom of the hull collapsed under the shock of impact and the boat was very quickly submerged to the level of the main planes. The captain and members of the crew made their escape and immediately endeavoured to rescue the passengers. Six of the nine passengers managed to save themselves or were rescued alive; the remaining three were drowned. Boats from the Phaleron Airport were quickly on the scene and assisted in the work of rescue. The cause of the accident must be attributed, the report states, to an error of judgment on the part of the pilot in that, instead of estimating his height by means of the horizon of the opposite coast, which was clearly outlined, or from the objects on the surface of the sea, such as floating buoys, boats, &c., which were numerous in the particular space of the airport in which he was to alight, the pilot estimated his height from observation of the sea and was misled by the smooth surface and the phenomenon of reflection characteristic of a complete calm. The pilot's previous flying experience had amounted approximately to 4000 hours in landplanes, and 200 hours in seaplanes. The failure to save all the passengers is to be attributed partly to the severity of the fracture of the aircraft, with a consequent rapid inrush of water into the hull—which was increased by the fact that the engines were not stopped immediately on impact—and partly to the fact that the facilities for exit from the passenger compartment to the upper part of the hull proved in such circumstances as those of this accident to be insufficient. All Empire flying-boats in service have now been provided with extra exits and their windows made to push out.

Voltage Regulators.

No. VI.

(*Continued from page 640, June 10th.*)

A QUICK-ACTING voltage regulator (Fig. 43), made by the Oerlikon Company, introduces or cuts out resistance directly by means of an electric measuring system, as in the case of the regulator described in the last article. It has other applications besides that of regulating pressure, such as the control of power factor; but voltage control is the application with which we are here mainly concerned.

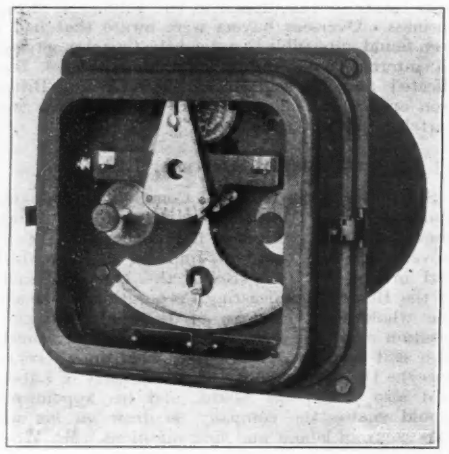
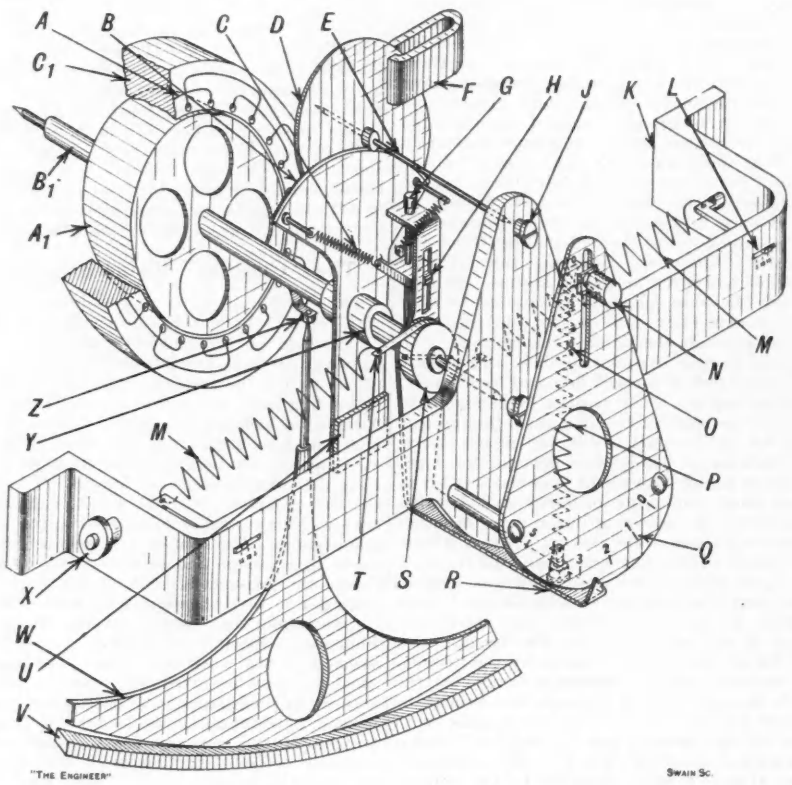


FIG. 43—OERLIKON VOLTAGE REGULATOR

There are three principal parts—a revolving or electric measuring system, a spring return device with a damping arrangement, and the regulating system. To the measuring system the pressure to be maintained constant is applied and it displaces the regulating system. The former operates on the Ferraris principle and consists of a drum (Fig. 44) surrounded by a stator with main and auxiliary windings A, the latter being in circuit with a condenser to give a phase displacement of 90 deg. in relation to the other winding. A straining pulley S with a pointer R attached to it is secured to the rotor spindle. The main springs M act on the pulley through the intermediary of the bands T, and when no pressure is applied to the measuring system they revolve the rotor spindle B_1 in an anti-clockwise direction up to a stop; the forces compensate each other in relation to the axis of the rotor so that there is no additional friction in the bearings. The rotor (Fig. 45) is composed of a combination of iron and copper, and as the iron in the rotor carries the magnetic flux a fixed iron core is unnecessary. With an input of about 20 VA the measuring system develops a torque of about 1000 gr. cm. and the consumption is claimed to be only about one-tenth of that of other systems giving half the torque. Another claim is that the heating error is very small, with the result that the operation of the regulator is practically the same irrespective of whether it is warm or cold. Frequency variations of from 48 to 52 cycles are said not to affect the pressure regulation by more than 0·4 per cent.

The sector B (Fig. 44) of the return device with a bearing bush Y is mounted freely on the rotor spindle B_1 and is accurately balanced by the counterweight U, whilst the sector is flexibly coupled to the rotor spindle by return springs C. By means of the adjusting screw G the point of attachment of these springs is shifted outwards or inwards, according to whether the coupling is to be rigid or yielding, and the adjustment for the return motion can be read on the scale H. Through the intermediary of a pinion the sector of the return device drives the damping disc D, which revolves in the gap between two powerful permanent magnets F, only one of which is shown. Eddy current braking is thus secured in the well-known way.

When a movement of the revolving system is brought about by an alteration of the quantity measured the return springs C are put under tension, thus producing a torque between the revolving system and return device, and the torque increases with the amount of the angular displacement. According to the adjustment of the damping and return motion, which must be regulated together, it is possible to arrange that the regulating system takes up the new position after two or three damped oscillations. By reason of the facility with which the damping and return motion can be adjusted, the regulator can be adapted to any machine and freedom from hunting can be ensured. The damping device also permits of considerable over-regulation in the case of heavy pressure fluctuations. In other words, it makes it possible for the regulating system to lead momentarily over the damping system and to pass the position corresponding to the new load conditions. By allowing for over-regulation for a short period the magnetic inertia of machines can be more rapidly overcome and the maximum speed of regulation can be attained.



A. Motive system windings.
B. Return motion sector.
C. Return motion spring.
D. Damping disc.
E. Spindle of damping disc.
F. Damping magnet.
G. Setting screw for return motion.
H. Scale for setting return motion device.
J. Bearing.
K. Yoke.
L. Scale for setting main springs.
M. Main springs.
N. Setting screw for static spring.
O. Scale for static adjustment.
P. Static spring.
Q. Scale for position of revolving system.
R. Pointer.
S. Straining pulley.
T. Attachment band.
U. Counterweight.
V. Contact path.
W. Contact sector.
X. Setting screw for main springs.
Y. Bearing bush for return motion.
Z. Jewel bearing for contact sector.
A_1. Rotor.
B_1. Rotor spindle.
C_1. Stator.

FIG. 44—DETAILS OF OERLIKON VOLTAGE REGULATOR

The rolling contact sector W is linked up with the rotor spindle through the jewel bearing Z, and a flat spring is forced to follow its angular displacement. The spring presses the contact sector against the contact path. To each segment of this path a resistance coil is connected so that as the sector moves the number of short-circuited segments is varied. When the generator is running light the pointer is, for instance, in the position 4 on the scale Q, and the point of contact of the sector is at the left end of the contact path. Only a small number of segments are then short-circuited. A large amount of resistance is then inserted in the exciter field circuit, but when the generator is on full load the pointer is in the neighbourhood of position 1. By providing a second sector as shown in Fig. 46 the capacity of the regulator can be doubled and the regulator can deal with large exciters.

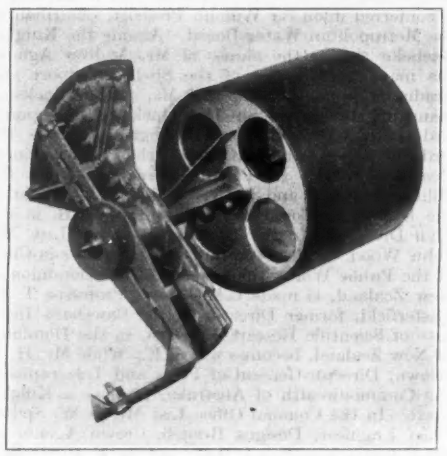


FIG. 45—REGULATOR ROTOR

Considering the adjustments of the regulator, let it be assumed that the regulator is without pressure and without the static spring P. The two main springs M then cause the revolving system to take up the position 0 on the scale Q when the main springs are shortened to the greatest extent and exert a definite torque on the revolving system. But if the revolving system be brought into the position 5 on the scale Q the two main springs are extended and the effort increases proportionally with their elongation and the torque exerted by them increases accordingly. In the position 0 the electric torque required for counter-balancing the torque of the springs is smaller than in the position 5; that is to say, the regulator operates in the position 0 for a lower pressure than in the position 5. By means of the spring P the torque on the main springs can be subjected to an additional influence. As shown, the spring P is attached at its lower end to the pointer R, whilst its upper end is attached to the adjusting screw N exactly above the centre of the rotor spindle and its tension can be varied by the screw N, when the result of the adjustment can be read on the scale Q. From the middle position to the end position 0 the spring P produces a torque which assists that of the main springs, while from the middle position to the end position 5 it acts in opposition to it. In this way the increase of the resultant mechanical torque can be reduced at will from the position 0 to position 5 and by making this

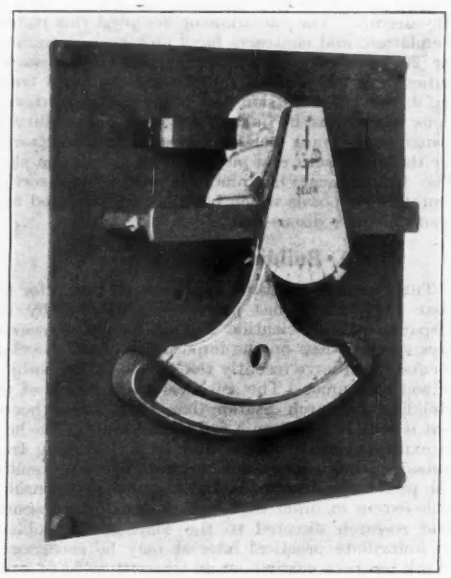
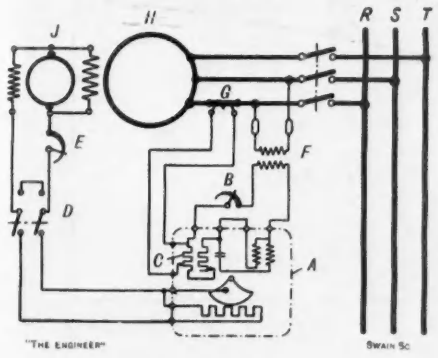


FIG. 46—TWO SECTOR REGULATOR

increase zero a constant mechanical torque can be obtained over the whole range. As the torques produced electrically and mechanically must balance each other, the regulator operates from light load to full load at exactly the same pressure. Such an adjustment of the regulator is described as astatic and is suitable only for generators working alone.

As explained in the previous article, when several generators are operating in parallel it may happen



A. Pressure regulator.
B. Pressure-adjusting resistance.
C. Resistance for compounding.
D. Reversing switch.
E. Adjusting resistance.
F. Potential transformer.
G. Current transformer.
H. Generator.
J. Exciter.

FIG. 47—CONNECTIONS FOR COMPENSATED REGULATOR

that the adjustment of the excitation is not the same in each case, and this results in uneven distribution of the wattless load. To remedy this the regulators are adjusted statically; that is to say, they regulate at light load at a pressure 4 per cent. higher than at full load. A definite value of pressure corresponds to each regulator position, and this ensures uniform excitation of the generators. To obtain a constant regulated pressure over the whole range of load in spite of the static adjustment of the regulator the latter is compensated electrically by means of the generator current. The generator pressure is applied as with other regulators through a potential transformer F (Fig. 47). In the circuit is an adjustable resistance B, by means of which the regulated pressure can be varied within wide limits, and the compensating resistance C in series with it. The latter which is also adjustable, carries the secondary current of the current transformer G, as at X in Fig. 40, *ante*. In this way an additional pressure component is introduced into the circuit with an absolute value directly proportional to the generator current and with a position in relation to the pressure of the system varying with the phase displacement of the generator current. In the no-load position equilibrium between electrical and mechanical torque is obtained for 100 per cent. pressure, while with the 4 per cent. static adjustment the equilibrium at full load is obtained for 100—4 per cent., or 96 per cent. pressure. To keep the pressure of the system at a 100 per cent. value at full load the pressure applied to the regulator must be reduced to 96 per cent. The compensating resistance is adjusted for the power factor and full-load current most often met with in such a way that the additional pressure on the resistance when added vectorally to the pressure of the system gives a regulator pressure exactly equal to 96 per cent.

If the machine tends to become over-excited in consequence of a drop in pressure of the system the power factor also decreases to the extent of an angle φ, for example. The additional pressure is added to the pressure of the system and as a result an excess regulator pressure is obtained. But the regulator reacts immediately and reduces the excitation of the generator, so that it transfers part of the wattless load to other machines. The conditions that obtain when the power factor is too high can be considered in a similar way.

If the pressure must be kept constant at the end of an overhead transmission line the result is achieved by causing the current of the latter to act on the regulator through another current transformer, as in Fig. 42, *ante*. In the case of machines working singly the result may be secured by causing the static curve to rise with increasing load and this can be done by tightening the static spring P (Fig. 44).

(To be continued.)

Control of Magnetic Quality by Surface Treatment.

By T. F. WALL, D.Sc., D.Eng.*

No. I.

INTRODUCTION.

IN a previous article† it was pointed out that the surface of a magnetisable wire of, say, nickel, iron, or cobalt might be expected to have an important influence on the magnetic quality of the wire in the aggregate for the following reason. If an element of the material near the axis of the wire be considered—that is to say, an element which is embedded in a mass of metal of its own kind—the molecular forces exerted on that element by the surrounding metal will be, in the aggregate, symmetrical. If, however, an element of metal at the surface of the wire be considered there must obviously be a very considerable dissymmetry of the external molecular forces which act on such an element.

Whatever the precise mechanism of magnetisation may be, a necessary consequence of such dissymmetry of molecular forces on the surface layer would appear to be that the magnetic quality will be different for a filament of the metal at the surface as compared with that of a filament near the axis of the wire. In view of these considerations, the relative influence of the surface on the magnetic quality of the wire in the aggregate might be expected to be a function of the diameter, so that by subjecting wires of different diameters to the same heat treatment a wide diversity of the magnetic quality of the wires might be expected to be disclosed.

Further, by treating the surface of the wire with a suitable non-magnetic material which would alloy with the surface layer, the dissymmetry of the molecular forces acting on the surface layer might be expected to be largely eliminated and the aggregate magnetic quality of the wire might be expected to be notably affected as compared with the magnetic quality of the uncoated wire of the same diameter and subjected to the same heat treatment.

In this article some results are given of tests which have been designed in accordance with the general considerations given in the foregoing. In the first part of the article the results on a series of pure nickel wires of diameters ranging from $\frac{1}{32}$in. to $\frac{9}{64}$in. diameter are given for which no surface treatment had been applied. The effect is then examined of copper-plating a similar series of nickel wires and subjecting them to the same heat treatment as the uncoated wires. The test data show that the effect of the copper coating is to improve the magnetic quality to a notable degree as regards permeability, coercive force, and hysteresis loss.

In the second part of the article a similar investigation for the case of Armco iron wire is considered and the same general results are obtained as for nickel wire. As regards the experiments on the effect of coating the iron wires with a suitable non-magnetic material, it was considered that manganese might be expected to have an important influence, it being observed that manganese stands next to iron in the atomic table whilst copper stands next to nickel.‡

It is not, however, obvious at first sight by what means a coating of manganese on iron wire could be effected, because, for example, the ordinary normal method of spraying could not be used, since manganese cannot be obtained in the form of wire, as is required for a spraying pistol. Through the courteous assistance of Mr. Kenneth Gray, however, the difficulty has been overcome. It is now possible to obtain wires coated with a layer of manganese by means of a spraying pistol which makes use of powdered manganese. Although the full series of tests on manganese coated iron wire has not yet been completed, the preliminary results given in what follows show that a remarkable improvement of the magnetic quality of the iron is obtained in this way.

In addition to the magnetic tests on the coated and the uncoated wires, measurements have been made of Young's modulus and also of the specific electric resistance. These non-magnetic tests of the physical properties of the wires of various diameters yield additional information as to the magnitude of the surface effect.

PART I.

Apparatus and Method of Investigation.—The samples of wire tested were straight pieces about 20in. long. The furnace for the heat treatment was specially designed for the purpose and was so arranged that the wire under test could be suspended from a hook so as to hang freely in the furnace tube. In this way contact between the wire and the incandescent parts of the furnace was avoided and consequently the risk of the wire absorbing impurities during the heat treatment was avoided. The heating element of the furnace was wound with "Kanthode" wire on a "pythagarous" tube of $\frac{7}{8}$in. internal diameter, 26in. long. The outer sheath of the furnace was a tube of a composite material of asbestos and cement, the space between the heating element and this sheath being filled with diatomaceous earth. In this way it was possible to carry out prolonged heat treatment of the wire under test at about 1350 deg. Cent., whilst the outer surface of the sheath was not much more than 100 deg. Cent.

The furnace temperature was calibrated by means of an optical pyrometer and periodic calibrations were made during the course of the tests. After the wire had been maintained at, say, 1300 deg. Cent. for about five hours the heating current was switched off and the furnace allowed to cool down to room temperature, this cooling process requiring from five to six hours.

In order to eliminate the possibility of the specimen becoming oxidised during the heat treatment, purified hydrogen gas was allowed to pass slowly through the furnace tube in which the wire was hung. The cleansing of the hydrogen from all traces of oxygen and moisture was obtained by passing it through a small furnace containing copper turnings or platinised asbestos at a temperature of about 800 deg. Cent. as shown in Fig. 1. After leaving this furnace the gas passed successively through two bottles of pyrogallic acid to extract any remaining traces of oxygen, then through a drying tower containing silica gel with colour indication for moisture content, and then through two drying towers containing calcium chloride to extract all traces of moisture. The purified hydrogen then passed into the furnace tube at the lower end and was led away from the upper end through a bottle containing sulphuric acid and so escaped into the atmosphere. A slow stream of hydrogen was maintained in this way from the time the furnace was started until it had finally cooled down again to the room temperature.

When the sample wire had been heated at the selected temperature for a known period of time and then cooled down to the room temperature, it was removed from the furnace, care being taken to avoid any mechanical stress. A search coil was then slipped on and fixed near the middle of the wire and the wire and search coil were together lowered into a large vertical solenoid of about 5ft. length. In this way the demagnetising effect of the ends of the specimen were kept negligibly small and it was possible to remove the wire from the furnace and place it in position in the solenoid ready for testing within about three minutes, without incurring any risk of mechanical stress. It is to be observed that the nickel wire specimens after heat treatment became exceedingly soft, so that any risk of slight bending had to be carefully avoided, otherwise the corresponding strain would have seriously affected the magnetic quality.

Since the investigation was mainly concerned with an examination of the magnetic characteristics in the region of maximum permeability, and as this condition occurred for values of the magnetising

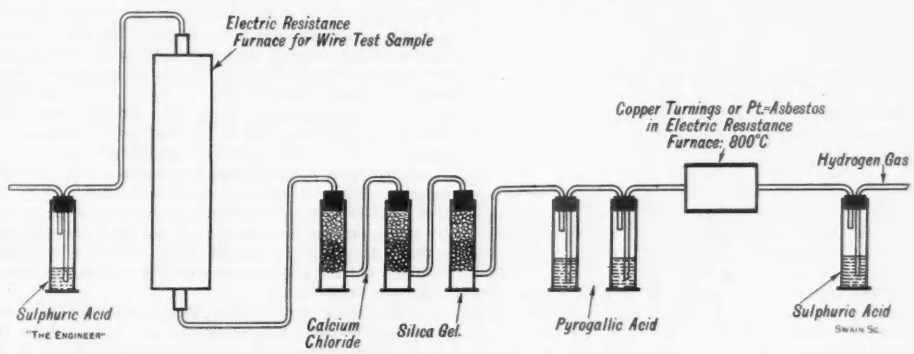


FIG. 1—APPARATUS FOR PURIFYING HYDROGEN

* Dept. of Electrical Engineering, University of Sheffield.

† THE ENGINEER, August, 13, 1937.

‡ THE ENGINEER, *loc. cit.*

force H which were comparable with the magnitude of the vertical component of the earth's field, it was necessary to neutralise this vertical component in the testing solenoid by means of a separate winding outside the magnetising winding supplied with a direct current of such a magnitude that the vertical component of the earth's field was neutralised, the

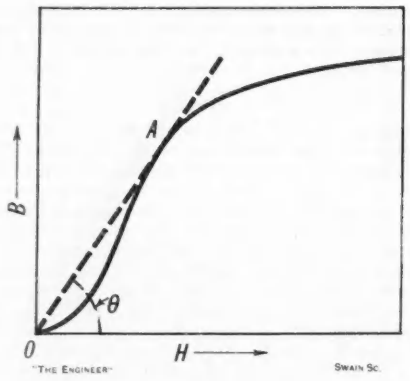


FIG. 2

required value of this direct current being found by actual test.

The ballistic galvanometer used was a Campbell high sensitivity instrument.

Tests on Nickel Wire.—Pure soft nickel wire was obtained of several diameters. The series now to be considered had the following diameters, viz., $\frac{1}{32}$in., $\frac{3}{64}$in., $\frac{5}{64}$in., $\frac{7}{64}$in., $\frac{9}{64}$in. Tests were made on wire of each gauge in the uncoated condition at a temperature of 1100 deg. to 1150 deg. Cent., and then a set of wires of the same diameters was electro-plated with copper to a thickness of about 0·002in. and heat treated in exactly the same way as the uncoated

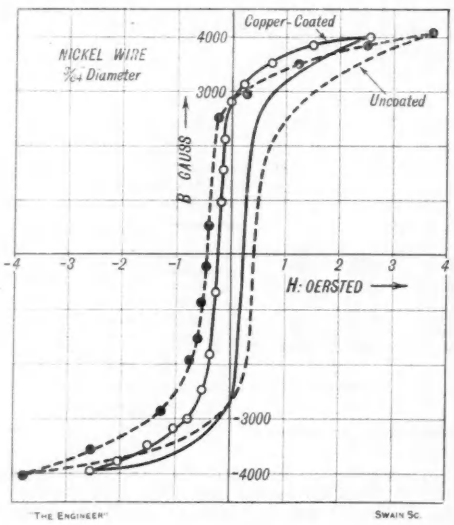


FIG. 6

wires. It is to be observed that the temperature of the heat treatment was such that the copper became molten and the superfluous copper which could not be absorbed by the nickel wire collected at the lower end of the wire as a drop. It was noticed that as the heat treatment proceeded the colour of the copper coating changed from a very beautiful orange to yellow and finally at about the condition of maximum permeability the colour became a drab grey.

After a definite period of heat treatment each sample was allowed to cool down and its magnetic properties tested, and this procedure was repeated until the condition of maximum permeability was obtained. Thus in Fig. 2 for any magnetisation curve the maximum permeability is given by the slope of the tangent O A to the curve. As the heat treatment proceeded it was found in general that the slope of the tangent O A increased to a maximum and then began to decrease. The test results considered in what follows refer to the condition for which the slope of the tangent had reached a maximum value; that is to say, the maximum value of the permeability referred to in what follows is defined as (see Fig. 2)

$$\mu_{max} = (\tan \theta)_{max}.$$

In Fig. 3 the lower curve shows the relationship between the values of μ_{max} and the diameter of the wire for uncoated nickel wires, and it will be seen from these results that the value of the maximum permeability increases as the diameter of the wire decreases. The upper curve in Fig. 3 shows the corresponding results for copper-coated nickel wires, and it will be seen that the values of the maximum permeability are considerably greater for the copper-coated wires than for the uncoated wires throughout the whole range of wires tested. The upper curve reaches a peak value for wire of about $\frac{3}{64}$in. diameter, in which case the maximum permeability is approximately double the value for the same diameter of uncoated wire. For wires of diameter smaller than $\frac{3}{64}$in. the value of the maximum permeability decreases rapidly. This fall can be partly accounted for by the fact that the copper-nickel alloyed surface layer will be more or less non-magnetic, so that the effective area of the wire for small diameters will be appreciably less than the area as calculated from the actual diameter of the wire.

In the lower curve of Fig. 3 the existence of a peak value is not definitely shown by the test results, but other tests indicate that the curve would fall in the way indicated in Fig. 3 for wires of diameter less than $\frac{1}{32}$in. The reason why test data for the maximum permeability of wires of diameter less than $\frac{1}{32}$in. are not shown in Fig. 3 is that difficulty has been found in obtaining delivery of such wires owing to the congested state of the manufacturers' works.

Hysteresis loops have also been obtained for the same series of wire diameters for both the uncoated and copper-coated wires, the peak value of all these hysteresis loops being an induction density of 4000 gauss. In Fig. 4 is shown the relationship between the coercive force H_c and the diameter of the wire for both the uncoated and copper-coated wires. In Fig. 5 are shown the values of the remanent induction density B_{rem} for the same series of wires. It is of interest to note that the curves in Fig. 4 show that the coercive force reaches a minimum value for wire of about $\frac{3}{64}$in. diameter. In Fig. 6 are shown the hysteresis loops for the wire of $\frac{3}{64}$in. diameter for the uncoated and copper-coated wires.

In Fig. 7 the magnetisation curves for $\frac{3}{64}$in. diameter nickel wire are given for a copper-coated sample heat treated to maximum permeability at 1100 deg. Cent. to 1150 deg. Cent. and an uncoated sample heat treated to maximum permeability at the same temperature.

In Fig. 8 are shown the results of measurements of the specific resistance of the wires, these measurements having been made in each case for the condition of maximum permeability. The rapid rise of the specific resistance of the copper-coated wire is of considerable interest as affording evidence of the actual alloying of the copper with the surface layer of the nickel wire, since such an alloy is known to have a relatively high specific resistance, and this effect will, of course, become more prominent as the diameter of the wire diminishes. The smaller rise of the curve for the uncoated nickel wire of small diameter is also of interest as indicating that the physical state of the surface layer of an uncoated wire is not the same as that of the core of the wire. This lack of homogeneity, which, of course, will be relatively more prominent for wires of small diameter, will afford an explanation of the fall in the value of the maximum permeability curve for uncoated wires of small diameter. The inference from this result, which will also be apparent in the corresponding curves given in Part II for Armco wires, is that the surface layer of uncoated wires is magnetically harder than the core of the wire.§

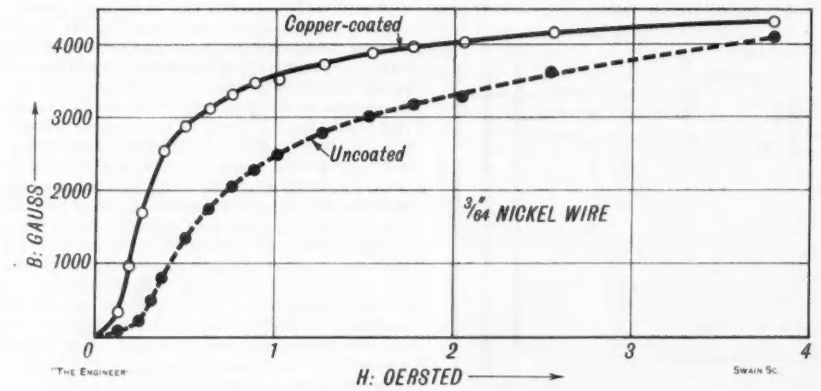
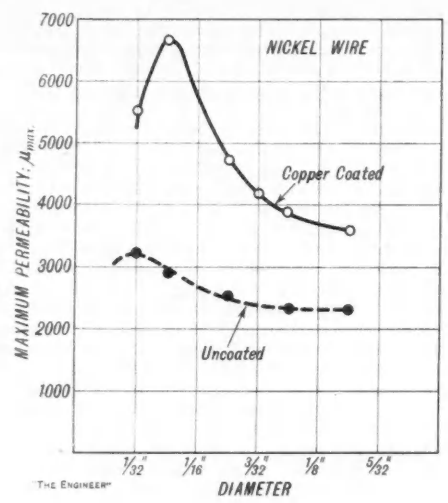
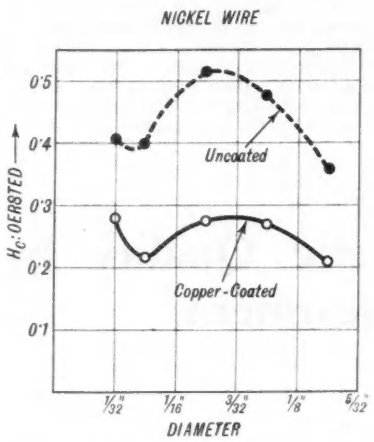
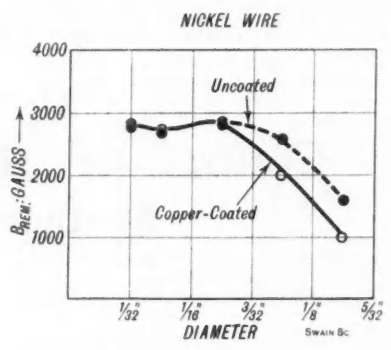


FIG. 7







FIGS. 3, 4 AND 5

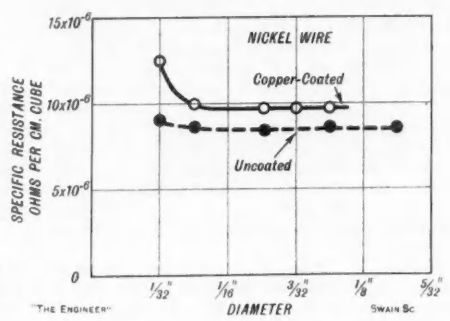
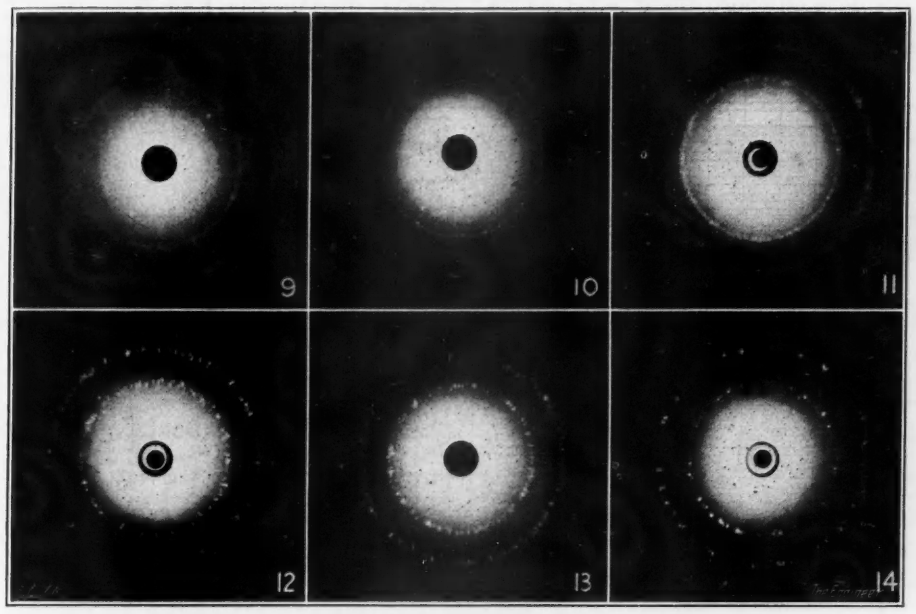


FIG. 8

X-ray Spectrograms.—In order to examine directly the nature of the contact between the copper coating

§ *Nature*, Vol. 141, January 29th, 1938.

and the surface of the nickel wire a series of X-ray spectrograms was taken, of which the most important are shown in Figs. 9 to 14. These spectrograms were obtained by the Philips' metallic apparatus and camera of the "back reflection" type. As both nickel and copper are of face-centred cubic lattice structure, direct measurements of the rings can be made to determine the alteration in the parameter measurements as follows :—



FIGS. 9 TO 14—SPECTROGRAMS FOR VARIOUS WIRES

Fig. No.	Description.	Diameter of ring.	Parameter measurement.
		Cm.	Cm.
9	Spectrographically pure copper	5·70	$3·603\times10^{-8}$
10	Untouched surface of copper-coated nickel wire	5·70	$3·603\times10^{-8}$
11	After 0·001 cm. had been removed from the surface of the copper-coated nickel wire ...	5·50	$3·571\times10^{-8}$
12	After 0·003 cm. had been removed from the surface of the copper-coated nickel wire ...	5·20	$3·523\times10^{-8}$
13	After 0·006 cm. had been removed from the surface of the copper-coated nickel wire ...	5·05	$3·499\times10^{-8}$
14	Uncoated nickel wire in the "as-received" condition	5·05	$3·499\times10^{-8}$

It will be seen from the parameter measurements for Figs. 9 and 10 that the untouched surface of the copper-coated nickel wire consists of pure copper, but as the surface is gradually removed so that the body of the nickel wire is approached the parameter measurement approaches that of pure nickel. These results show that a solid solution of copper-nickel has been formed at the contact of the copper coating and the nickel surface and that this solution becomes gradually richer in nickel as the body of the nickel wire is approached.

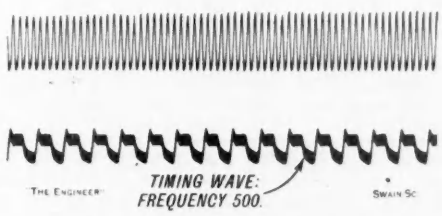


FIG. 15—TYPICAL OSCILLOGRAM

Young's Modulus Measurements.—In order to obtain from another point of view direct information as to the influence of the surface of a wire on its physical properties, measurements were made of the value of Young's modulus for nickel wire of various diameters in the "as received" condition, and also after heat treatment. The values of the modulus were obtained for both uncoated and copper-coated nickel wires of various diameters.

The electro-magnetic method‖ for measuring Young's modulus was used. This method depends upon the fact that, in general, the magnetic permeability of nickel, iron, and cobalt wires is affected by the state of mechanical stress of the wire. If the wire to be tested is suspended vertically in a steady magnetic field and is firmly clamped at the suspended end it may be caused to execute longitudinal vibrations at its natural frequency by stroking it, for example, with a piece of chamois leather on which powdered resin has been spread. When the wire is vibrating in this way the corresponding changes of stress will produce corresponding changes of the magnetic permeability and consequently corresponding changes of magnetic flux in the wire. If a suitable search coil is threaded over the wire and fixed in position so that it is not touched by the vibrating wire (otherwise the natural frequency will be interfered with), an E.M.F. will be induced in the search coil of the same frequency as the vibrations of the wire. If an oscillogram is taken of this induced E.M.F., and on the same oscillogram is recorded a timing wave obtained from, say, a standard tuning fork of known frequency, the frequency of longitudinal vibration of the wire is at once found. It is of interest to observe that in many cases the wire may be simply suspended in the earth's field without the necessity of using a D.C. excited solenoid to produce the steady magnetic field in the wire.

It is easy to show that, for a wire which is clamped at one end only, the value of Young's modulus E is given by the expression :

$$E=14·5\times\rho\ (4fl)^2\times10^{-6}\text{ lb. per square inch,}$$

where

ρ is the density of the wire in grammes per cubic centimetre ;

f is the measured frequency of longitudinal vibrations of the wire ;

l cm. is the free vibrating length of the wire.

If the wire is clamped at both ends the expression for the modulus becomes

$$E=14·5\times\rho\ (2fl)^2\times10^{-6}\text{ lb. per square inch.}$$

For wires of diameters less than, say, about $\frac{1}{32}$in., it has been found convenient to clamp the wire at both ends.

In Fig. 15 is shown a typical oscillogram as obtained for a heat-treated uncoated nickel wire $^3/_{64}$in. diameter. The wire was clamped at one end, the free vibrating length being $l=52·5$ cm. The frequency found from the oscillogram is $f=2050$, and the density is $\rho=8·9$, so that

$(4fl)^2=0·184\times10^{12}$, and $E=23·6\times10^6$ lb. per square inch.

In Fig. 16 are shown the values of Young's modulus as obtained in this way for nickel wires of various diameters (i) in the annealed "as received" condition,

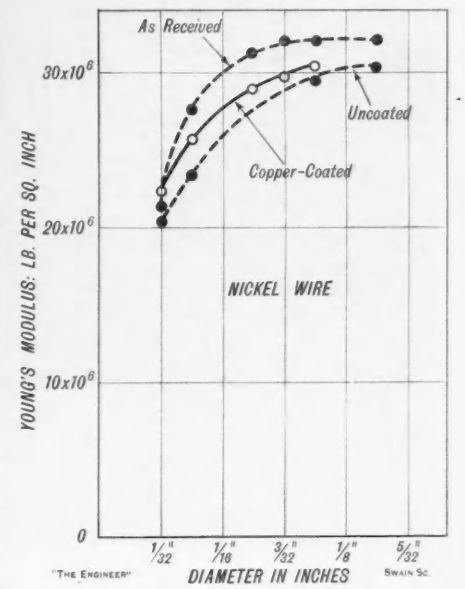


FIG. 16—YOUNG'S MODULUS FOR NICKEL WIRES

(ii) uncoated and heat treated to the condition of maximum permeability, (iii) copper coated and heat treated to the condition of maximum permeability.

The outstanding characteristic of each of the curves given in Fig. 16 is that for wires less than about $\frac{1}{32}$in. diameter, the value of the modulus rapidly decreases as the diameter of the wire decreases. It is also seen that the curves for the heat-treated wires lie below the curve for the wire in the "as received" condition. The curve for the copper-plated wires lies above that for the uncoated wires, and it is probable that this is largely due to the controlling influence of the nickel-copper alloy surface formed by the heat treatment.

(To be continued.)

‖ *Nature*, 131, p. 351, 1934. See also *Journal*, Institution of Electrical Engineers, 75, December, 1934.

Empire Exhibition, Glasgow.

No. VII.

(Continued from page 647, June 10th.)

IN our issue of May 6th we gave a description of some of the features of Bellahouston Park and the buildings at the Exhibition. In what follows we continue this description.

THE PARK AND BUILDINGS.

By D. BETHUNE-WILLIAMS.

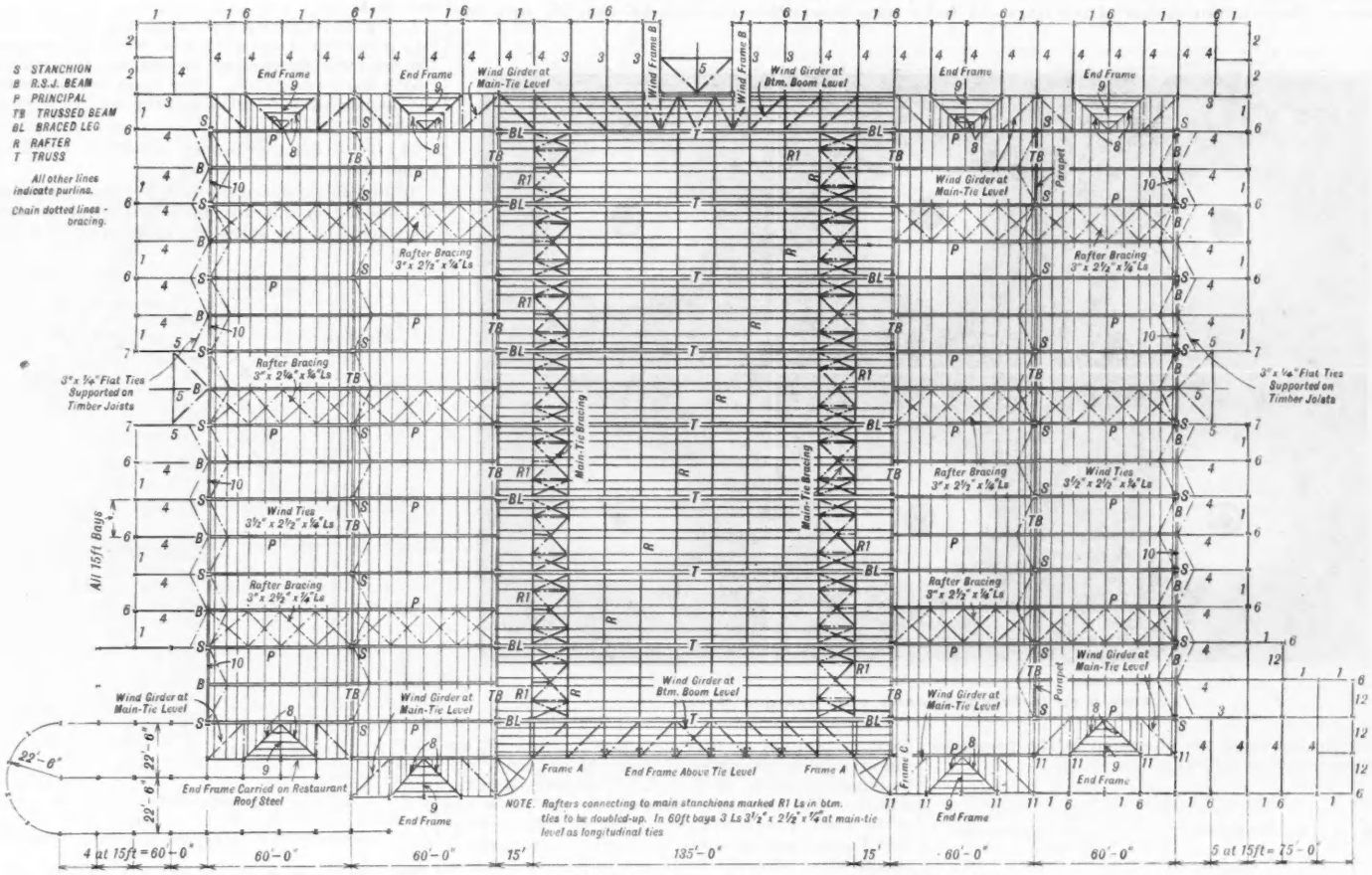
The construction of the buildings of a temporary exhibition, whose duration in this case is limited to six months, is a problem requiring the closest consideration of the designers. The Crystal Palace was probably the most brilliant essay in exhibition construction, utilising as it did the latest structural materials and carrying to the logical limit the idea of the standard unit. Specifically designed to meet the conditions of speed of erection, cheapness, and magnificence, it also combined with these qualities the maximum ease of dismantling ; such a building cannot be hoped to be found in Bellahouston Park.

Various exhibitions have not been so fortunate as the Crystal Palace. The tattered remnants of the once fashionable Earls Court encumbered the site and lingered on until cleared away for the present vast concrete building. The concrete-built palaces of Wembley still survive and are used as workshops or factories. Paris, though farsighted in retaining from its earlier exhibitions the triumphant Eiffel Tower, the Pont Alexander III, and other buildings, including the now rebuilt Trocadero, is at present proceeding with the demolition of the reinforced concrete used in buildings of the 1937 Exhibition.

It is in the light of these other buildings that Bellahouston Park must be considered. It must be admitted that little can be said to have been contributed by the Exhibition buildings to a new design or knowledge of materials. The brickwork is ordinary bearing construction, the steelwork is orthodox, the reinforced concrete where it is used in pools and so on is normal, and the timber construction shows no development over the war-time factory. The construction of the buildings does, however, deserve attention as exhibitions are comparatively rare in this country, and the developments in building technique are pointers for permanent construction.

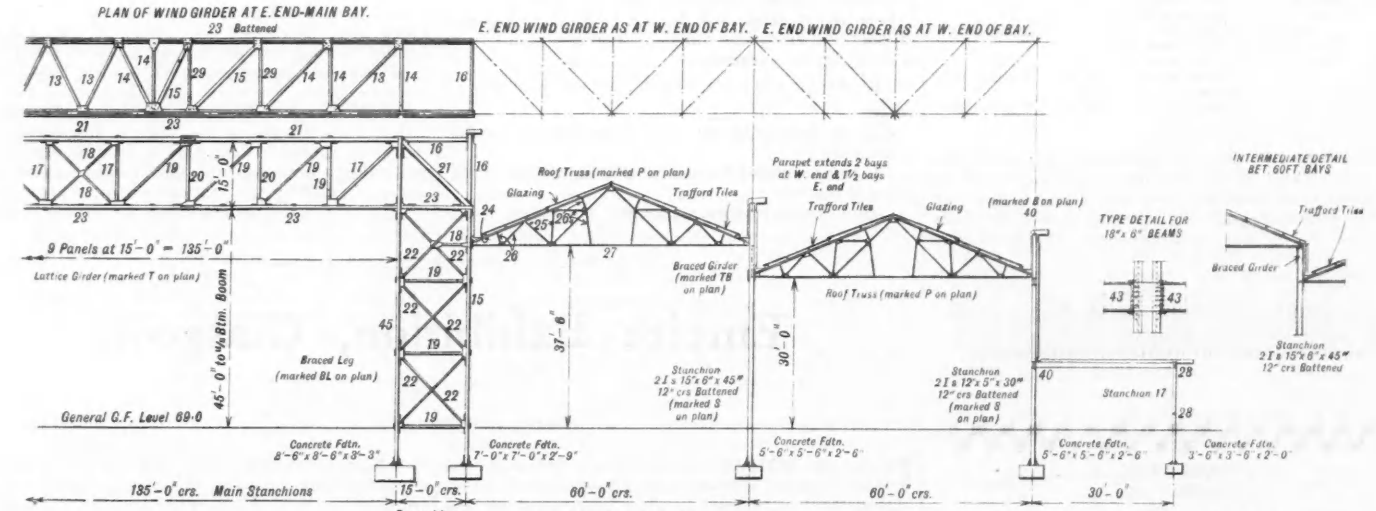
The Art Gallery is one of the few permanent buildings. It is of bearing construction, the walls and piers supporting light steel roof trusses with timber purlins covered with Robertsons protected metal sheeting, into which are set patented glazing roof lights. The floors are wood joists on sleeper walls with the usual damp-proof courses. The external walls are finished with precast slabs, 19in. square and 1½in. thick, applied as facing. The main electrical sub-station, a simple rectangular hall, is also of bearing construction, and accommodates switchgear and transformers of a capacity of 12/15,000 kVA. The site was fortunate in having 20,000-volt cables already laid in the grounds. From the sub-station 6000-volt underground ring mains run out to ten subsidiary sub-stations, some of 800 and some 1600 kVA capacity. The floor of the main transformer station is about 6ft. above the natural level of the ground, and had to be constructed to carry two main transformers weighing over 30 tons

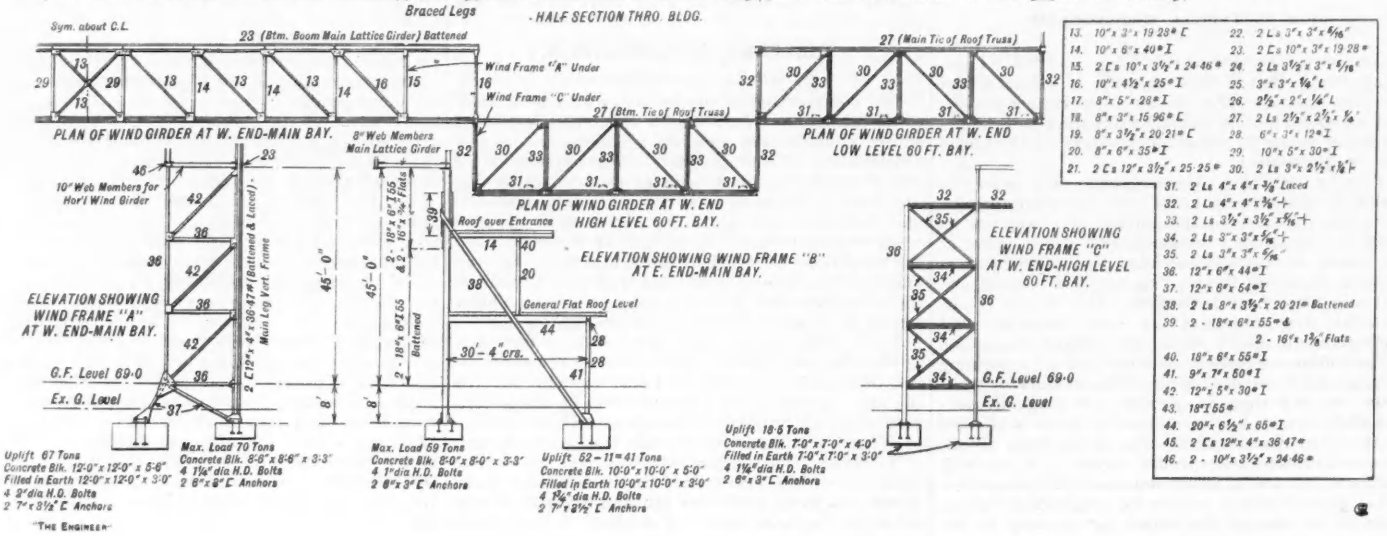
GLASGOW EXHIBITION—PALACE OF ENGINEERING



"THE ENGINEER"

1 = 2 - 6" x 3" I 12
2 = 8" x 6" I 35, 6" x 3" 12H Rail
3 = 20" x 6½" I 65
4 = 16" x 6" I 50
5 = 10" x 6" I 40H.L.
6 = 8" I 28
7 = 9" I 50
8 = 9" x 4" I 21 Hip
9 = 9" x 4" I 21 Rafter
10 = 18" x 6" I 55 HL. & LL.
11 = 12" I 44
12 = 8" x 6" I 35, 6" x 3" 12 I Rail


PLAN OF WIND GIRDER AT E. END-MAIN BAY.
E. END WIND GIRDER AS AT W. END OF BAY.
E. END WIND GIRDER AS AT W. END OF BAY.
9 Panels at 15'-0" = 135'-0"
Lattice Girder (marked T on plan)
45'-0" to ⅛ Btm. Boom
Braced Leg (marked BL on plan)
General G.F. Level 69·0
Roof Truss (marked P on plan)
Glazing
Trafford Tiles
Braced Girder (marked TB on plan)
Parapet extends 2 bays at W. end & 1½ bays E. end
Roof Truss (marked P on plan)
Stanchion 2 I s 15"x 6" x 45" 12" crs Battened (marked S on plan)
Stanchion 2 I s 12" x 5" x 30" 12" crs Battened (marked S on plan)
Stanchion 17
37'-6"
30'-0"
TYPE DETAIL FOR 18" x 6" BEAMS
INTERMEDIATE DETAIL BET. 60FT. BAYS
Concrete Fdtn. 8'-6" x 8'-6" x 3'-3"
Concrete Fdtn. 7'-0" x 7'-0" x 2'-9"
Concrete Fdtn. 5'-6" x 5'-6" x 2'-6"
Concrete Fdtn. 5'-6" x 5'-6" x 2'-6"
Concrete Fdtn. 3'-6" x 3'-6" x 2'-0"
135'-0" crs. Main Stanchions
15'-0" crs. Braced Legs
60'-0" crs.
60'-0" crs.
30'-0"
HALF SECTION THRO. BLDG.


Sym. about C.L.
23 (Btm. Boom Main Lattice Girder) Battened
27 (Main Tie of Roof Truss)
Wind Frame "A" Under
Wind Frame "C" Under
27 (Btm. Tie of Roof Truss)
PLAN OF WIND GIRDER AT W. END-MAIN BAY.
PLAN OF WIND GIRDER AT W. END LOW LEVEL 60 FT. BAY.
PLAN OF WIND GIRDER AT W. END HIGH LEVEL 60 FT. BAY.
10" Web Members for Hor'l Wind Girder
8" Web Members Main Lattice Girder
Roof over Entrance
General Flat Roof Level
ELEVATION SHOWING WIND FRAME "A" AT W. END-MAIN BAY.
ELEVATION SHOWING WIND FRAME "B" AT E. END-MAIN BAY.
ELEVATION SHOWING WIND FRAME "C" AT W. END-HIGH LEVEL 60 FT. BAY.
G.F. Level 69·0
Ex. G. Level
45'-0"
8'
30'-4" crs.
Uplift 67 Tons
Concrete Blk. 12'-0" x 12'-0" x 5'-6"
Filled in Earth 12'-0" x 12'-0" x 3'-0"
4 2" dia H.D. Bolts
2 7" x 3½" C Anchors
Max. Load 70 Tons
Concrete Blk. 8'-6" x 8'-6" x 3'-3"
4 1⅛" dia H.D. Bolts
2 6" x 8" C Anchors
Max. Load 59 Tons
Concrete Blk. 8'-0" x 8'-0" x 3'-3"
4 1" dia H.D. Bolts
2 6" x 3" C Anchors
Uplift 52 — 11 = 41 Tons
Concrete Blk. 10'-0" x 10'-0" x 5'-0"
Filled in Earth 10'-0" x 10'-0" x 3'-0"
4 1⅛" dia H.D. Bolts
2 7" x 3½" C Anchors
Uplift 18·6 Tons
Concrete Blk. 7'-0" x 7'-0" x 4'-0"
Filled in Earth 7'-0" x 7'-0" x 3'-0"
4 1⅛" dia H.D. Bolts
2 6" x 3" C Anchors

13.	10" x 3" x 19·28# C	22.	2 L s 3" x 3" x 5/16"
14.	10" x 6" x 40# I	23.	2 C s 10" x 3" x 19·28#
15.	2 C s 10" x 3½" x 24·46#	24.	2 Ls 3½" x 3" x 5/16"
16.	10" x 4½" x 25# I	25.	3" x 3" x ⅝" L
17.	8" x 5" x 28# I	26.	2½" x 2" x ⅛" L
18.	8" x 3" x 15·96# C	27.	2 Ls 2½" x 2½" x ⅛"
19.	8" x 3½" x 20·21# C	28.	6" x 3" x 12# I
20.	8" x 6" x 35# I	29.	10" x 5" x 30# I
21.	2 C s 12" x 3½" x 25·25#	30.	2 Ls 3" x 2½" x ⅛"
		31.	2 Ls 4" x 4" x ⅜" Laced
		32.	2 Ls 4" x 4" x ⅜"
		33.	2 Ls 3½" x 3½" x 5/16"
		34.	2 Ls 3" x 3" x 5/16"
		35.	2 Ls 3" x 3" x 5/16"
		36.	12" x 6" x 44# I
		37.	12" x 6" x 54# I
		38.	2 Ls 8" x 3½" x 20·21# Battened
		39.	2 - 18" x 6" x 55# & 2 - 16" x 1⅜" Flats
		40.	18" x 6" x 55# I
		41.	9" x 7" x 50# I
		42.	12" x 5" x 30# I
		43.	18" I 55#
		44.	20" x 6½" x 65# I
		45.	2 C s 12" x 4" x 36·47#
		46.	2 - 10" x 3½" x 24·46#

"THE ENGINEER"

each and two smaller units of 5 tons each, together with switchgear of quite considerable weight. It was uneconomical to design the whole floor to carry a point load of 7½ tons. It was therefore designed by the architects to carry only 1¼-ton point loads over that part of its area assigned to the smaller transformers and switchgear. The floor is carried on piers and is constructed of concrete and filler joists to facilitate demolition. The 6in. slab was stiffened to take the 30-ton loads on four special tracks leading from the door openings. These tracks were formed of twin 6in. by 5in. I beams, and on them were laid guides for the wheels in the form of channels with the flanges upturned to prevent displacement. The roof is composed of light concrete slabs carried on steel beams bearing on the piers which stiffen the external walls.

With a few exceptions the other buildings some of which are illustrated herewith and on page 678, are constructed of steel or timber frameworks, or combinations thereof. The loading for all the buildings on the site, with the exception of the Tower of Empire, was laid down by the Glasgow Dean of Guild Court. It was stipulated that the designs should allow for wind loading at 30 lb. per square foot, on all exposed vertical faces, the resolved component on sloping roofs being computed by Duchenion's formula. Flat roofs were to be designed to carry a superimposed load of 30 lb. per square foot. Corridors and staircases accessible to the public were to carry 150 lb. per square foot, and general public spaces not less than 100 lb. per square foot. The steel frameworks generally conform with B.S.S. 449, but no standard specification appears to cover timber.

The largest building on the site, the Palace of Engineering, has a complete steel skeleton, shown in the drawings reproduced on the opposite page, which was designed for the architect by Mr. John F. Farquharson, M. I. Struct. E. This building has an extreme length of over 540ft. and an extreme depth of over 330ft. The height to the top of the roof girders in the main hall is 60ft., the façade being carried up to mask the trusses. The building is set out on a grid of 15ft. in each direction and vertically, the column centres and the roof heights being multiples of this unit. The lay-out consists of a central hall, 255ft. by 135ft. between centres of columns, separated by double stanchions on 15ft. centres on both sides from the stepped-down side halls, consisting of four 60ft. spans. Around these five halls on the north, east, and south sides runs at a still lower level a 30ft. bay. The northern end of the main façade is occupied by restaurants on the ground and first floors, while the central portion forms the great entrance hall. The central hall is spanned by 15ft. deep N lattice girders at 30ft. centres, supported on which are pitched trusses of 15ft. span at 15ft. centres. The side halls have simple pitched trusses of 60ft. span at 15ft. centres sloping at 23 deg. The ends of these trusses are hipped back to obviate raising the parapets concealing them. The lowest bay and the restaurants are spanned with steel beams carrying wood joists.

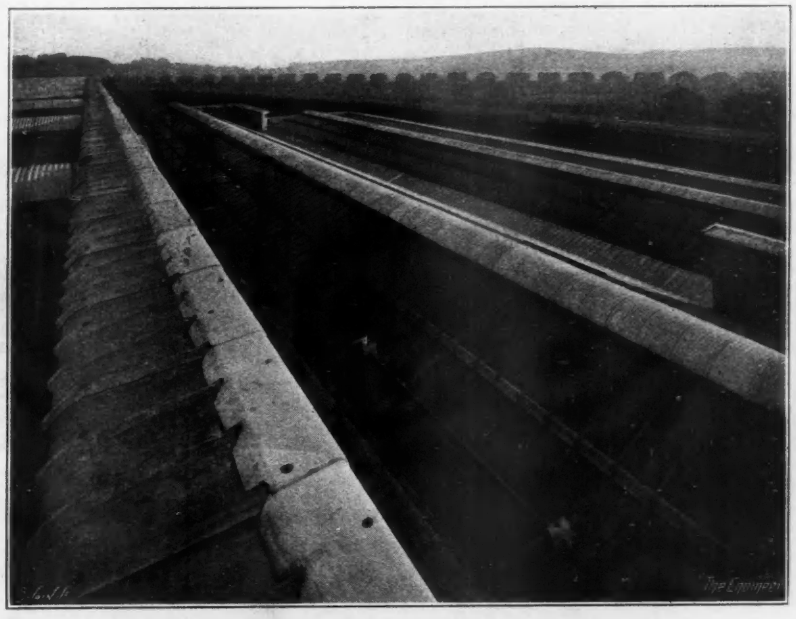
A feature of this building is the provision made for wind stresses, the loading being taken up both laterally and longitudinally. For architectural reasons, knee braces were considered undesirable on the side spans. Consequently, the whole of the lateral wind load, from the side walls of the building and from the roof slopes, had to be provided for in the centre span construction. This course necessitated designing the double line of stanchions on either side of the central hall to act as portal frames in conjunction with the main roof girder. These stanchions on 15ft. centres are cross braced in 15ft. bays throughout their height, except in certain bays where a clear way was required for stands. At such positions the bottom 15ft. bay of bracing was omitted and a lattice girder and extra reinforcing members, bolted to the main legs, were provided to stiffen the legs to take up the loading as a portal. The inner leg of these main frames consists of two 12in. by 4in. channels and the outer leg of two 10in. by 3½in. channels, both laced at 60 deg. with 2½in. by ⅜in. flats. The diagonal bracing consists of double 3in. by 3in. by ⅜in. angles. The stanchions were anchored to the foundations by four 1in. diameter bolts, 2ft. long, and two 6in. by 3in. channel anchor plates.

It may be noted that the top boom of the girders is composed of two 12in. by 3½in. channels and the bottom boom of two 10in. by 3in., both laced at 60 deg. with 2½in. by ⅜in. flats. The booms were set out with an initial camber of 4in. at the centre on the 135ft. span. The diagonal web members are crossed 8in. by 3in. channels in the centre bay and 8in. by 3½in. single channels elsewhere, except at the end bay which has 8in. by 5in. I members. The verticals run through at 8in. by 5in. I, 8in. by 6in. I, and two 8in. by 3½in. double channels in the end bay. The central columns, carrying the two side spans of 60ft., are composed of twin 15in. by 6in. joists battened; those at the outer ends of the spans are twin 12in. joists.

The wind pressure on the ends of the building is transmitted to the main lines of stanchions by wind girders of horizontal N lattice trusses, bracing the bottom boom of the end main girders. The longitudinal lattice girders, between the stanchions, act with these as portals, in addition to supporting the intermediate trusses of the 60ft. side spans. The wind reaction along the line of the inside leg of the braced stanchions in the central hall is taken up by vertical wind frames at the two ends of the building, the concrete foundations being large enough to take the uplift. It may be noted that this pavilion was erected on particularly bad peaty ground, and the bases were generally designed only for about 1 ton per square foot. The building was erected by Sir William Arrol and Co., of Glasgow, and the tonnage of steel used in it was 1300.

INTERIOR VIEW OF THE PALACE OF INDUSTRIES WEST

For the Palace of Industries West the structural consulting engineer for the architects was also Mr. John F. Farquharson. This building is the second largest on the site, with its curved front closing the western end of Dominion and Colonial avenues. It is planned as a main building over 500ft. long by 150ft. deep, from which projects a central wing 180ft. by 90ft., and projecting radially two smaller wings 92ft. by 62ft. centres of columns. The main building is in two spans of 60ft. roofed with pitched trusses, set out radially, the average spacing being about 14ft. Stanchions are placed at 28ft. centres except in the walls of the wings and a portion of the front wall where there are stanchions under each truss. The building is curved in plan, being swept from the same centre as the façade, but the engineer by careful design has eliminated the use of expensive curved members and the whole structure is built up with straight sections. The setting out, however, was no easy matter.



ROOF CONSTRUCTION OF THE PALACE OF ENGINEERING

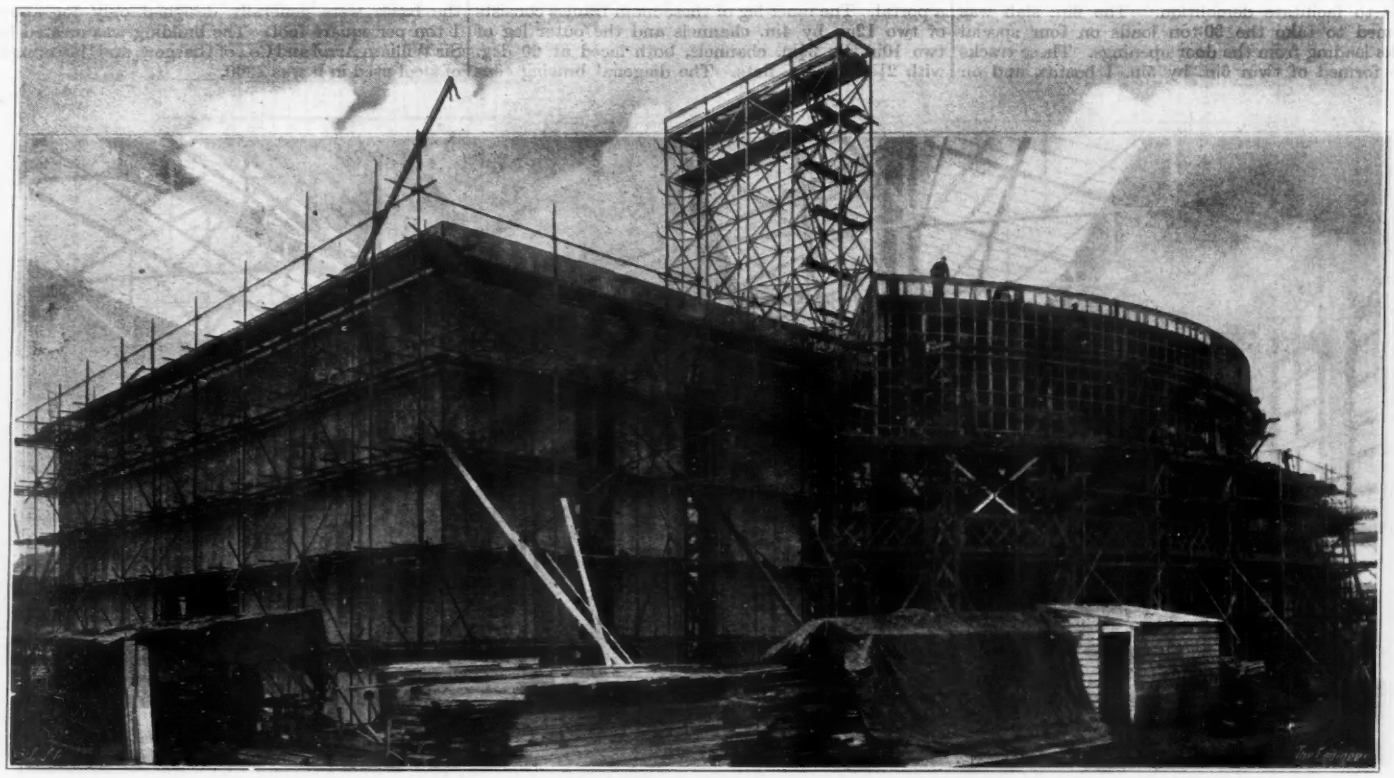
The height to the apex of the trusses is 43ft., and the trusses and stanchions are designed as portals to withstand the wind loading. Horizontal wind girders are placed at the level of the eaves at the

ends of the wings, where the wind load has to be transmitted from the intermediate stanchions to the main line. At one end of the main building there is a tower, 16ft. by 3ft. 6in. in cross section, and 74ft. high, with an illuminated sign projecting on the shorter side. This tower is constructed of channel uprights braced with angles, and the wind load is transmitted to the main building by means of braced frames. The total weight of steel used in the building, including the restaurants at the ends, was 900 tons. The building was erected by Redpath, Brown and Co., Ltd.

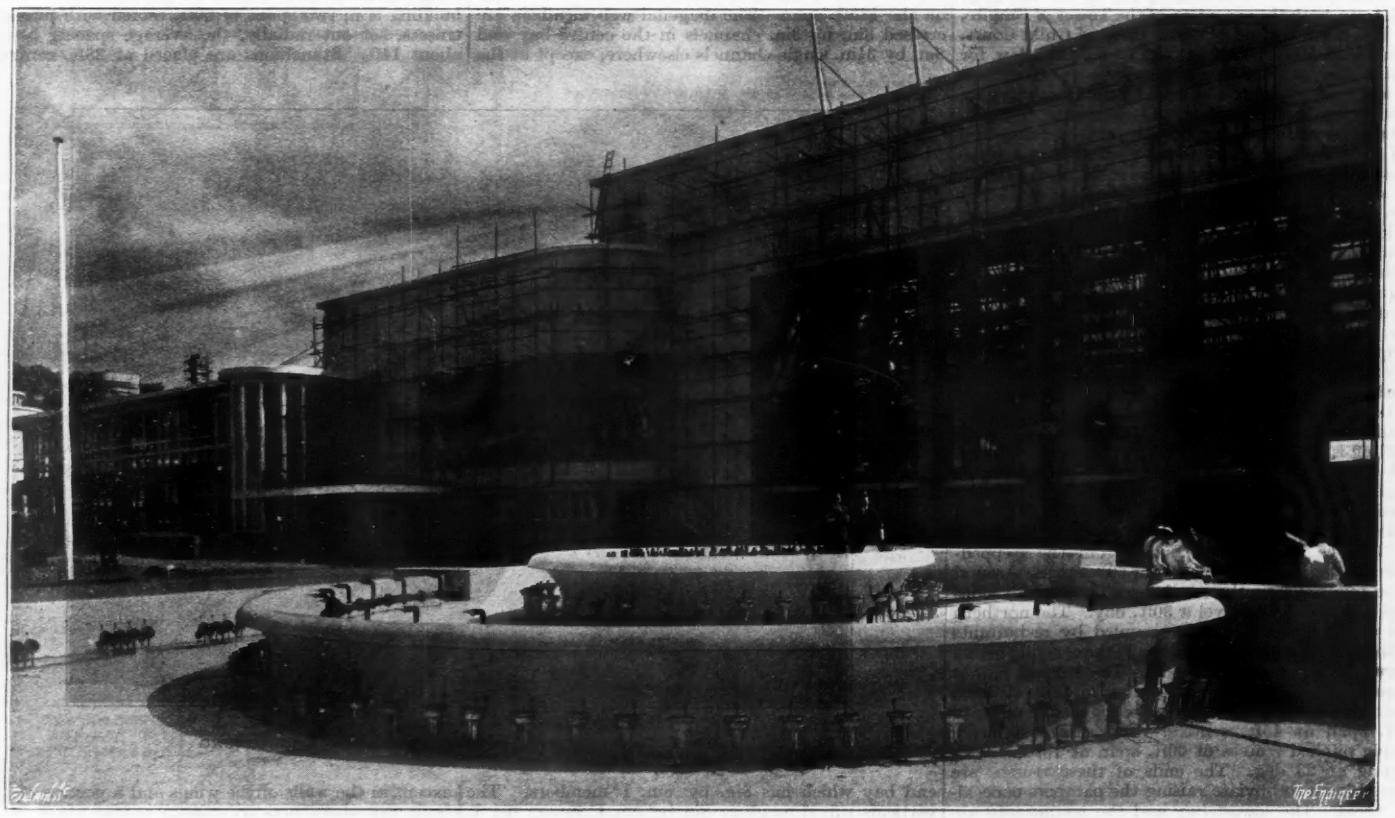
The roofing of the Palaces of Engineering and Industries West is carried out with "Trafford" tile asbestos sheeting, supplied by Turners Asbestos Cement Company. In the roofs are incorporated generous areas of patented glazing, providing good natural lighting. Along the ridges of the buildings provision is made for natural ventilation by extracts through curved sheets. The floors generally in the two buildings are raised above the natural ground, and this fact has caused some difficulty, the heavy exhibits requiring big concrete plinths. The flooring for lighter loads consists of timber boarding carried on wood joists, these, in turn, bearing on steel beams resting on piers; the floors thus form a convenient service duct. The floors to the terrace of the Industries Pavilion are formed with Turnall slabs on wood joists.

Both these buildings have their walling formed of Turners asbestos sheeting. The problem that had to be solved required the closest co-operation by the manufacturers and the engineer with the architects, and it was only after considerable trouble, thought, and experiment that the present successful results were obtained. The difficulty to be overcome was the method of obtaining a satisfactory weather-proof finish easily fixed and easily dismantled, and yet presenting a pleasing surface lending itself to a treatment of broad masses, and at the same time adaptable to curved as well as flat walls. The normal methods of clipping the sheets to steel sheeting rails was both expensive and unsuitable, the lapping and clips tending to destroy the unity of the surface and to produce an undesirably "temporary" feeling in the buildings.

The problem was solved by the use of composite construction. At standard unit heights along the outside steel stanchions steel sheeting rails were provided sufficiently strong to take the vertical loading. The horizontal load was transmitted by horizontal wood studding, supported by short wood studs bearing on timber runners attached to the steel rails by bolts. This use of subsidiary timber studding assisted the fabrication of the steelwork as it released the work from waiting for the minutest detail of the architectural finish; at the same time, it afforded a system of fixing having flush weather-proof faces. To ensure a proper finish in accordance with the architectural drawings, a number of sheets were set out full size.



CANADIAN PAVILION



FOUNTAINS OUTSIDE PALACE OF ENGINEERING

This application of cement asbestos materials, including also the various pressed copings, column casings, and other details, is the most noticeable improvement in technique attributable to the Exhibition. The construction described above holds good for the majority of the steel-framed buildings except the Coal Pavilion, which has as walling corrugated sheeting or those with cedar sidings.

The Concert Hall provides a slight exception to the general rule, as in this case the sheeting rails are on the inside of the built-up lattice columns,

NIGHT DISPLAY AT THE NORTH END OF THE GREAT LAKE

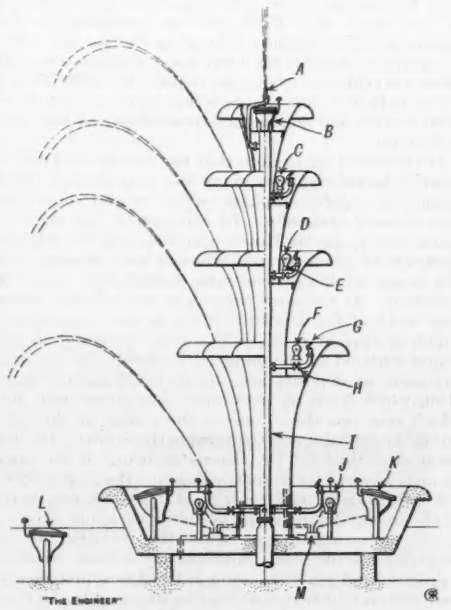
and the columns are moulded as projecting decorative ribs. The Concert Hall is spanned by 90ft. lattice girders which, with the main stanchions, form portals taking up the wind loading. Where the main columns stop over the smaller halls, twin girders are introduced to take up the bending and other forces in the "leg" of the portal. These girders also support the back of the auditorium which, at that position, is raked up to above the first floor level.

The floor of the auditorium is of different construction from that of the other buildings. Having in mind the temporary nature of the building and the scrap value of the materials used in it, the architects designed the floor construction to minimise the amount of special work involved. The floor is constructed of 9in. by 2in. planks laid on the flat spanning 6ft. on to stepped blocks, cut from 9in. by 3in. timber, which form the bearings both for the treads and the risers. These blocks are spiked to 4in. by 3in. runners which are in turn bolted to the steel joist rakers, these last being plain beams holed every 2ft. to 3ft. for bolts, and carried on beams at the higher levels or struts at the lower. The floor system, although unusual, has been found to be satisfactory for fire risks and chair fixing. The end walls of the stage are stiffened with external ribs and the single-storey buildings are steel framed. The restaurant on the first floor over the entrance foyer is constructed with wood floor and roof joists carried on a steel framework of which the beams at both levels cantilever out beyond the stanchions. The front is formed of glass and wood, and in this connection it must be admitted that whereas any wall that is opaque must be designed to carry heavy wind loading, when these walls are replaced by glass the requirement seems to be very liberally interpreted, or else the wood window mullions are over stressed—in theory.

Turning from this building, the steel work of which was erected by A. and J. Main, Ltd., to the two Scottish Pavilions, also of that firm's erection, the most interesting feature to be noted is the heavy diagonal wind bracing in the high entrance halls and the construction of the high fin-like projection or tower. The bracing on the narrow front is of solid web plate members and on the returned longer side of diagonal lattice. The British Government Pavilion, the highest on the site, is also noticeably well braced and is a composite wood and steel-frame structure. The grand collonade along the front is of built-up lattice timber and carries at the top lattice timber trusses. The walls of this pavilion are of "Hyrib" and rendering and are extensively braced by diagonal members. The parabolic vaulting is of wood construction, within which are the steel stanchions.

The Coal Pavilion, of 70ft. span, was erected by Redpath Brown at a late stage in the job, but its construction is not evident, as is that of the Amusement Park Restaurant, where the light steel beams and stanchions are exposed and form part of the decorative scheme. The majority of the remaining buildings are of timber framework and it was most noticeable during construction that few of them showed the diagonal bracing of the steel work, lateral stiffness apparently being relied upon in the coverings.

The biggest pavilion in area after the Engineering and Industry West Palaces is the Palace of Industry North. This structure has a timber framework, but from the point of view of detailing the Canadian Pavilion is one of the best. Here the Howe truss and the multiple lattice were carefully designed and properly carried out. The bracing has received careful attention and provision for wind is made in diagonal bracing, both in the horizontal and vertical planes. The high central tower is of steel work. Adjoining the Canadian is the New Zealand Pavilion, also a timber structure and one of the few employing diagonal sheathing for lateral stiffness. Next door is the South African Pavilion, designed on the lines of an old Dutch gabled farmhouse. Its construction is, however, a steel frame with timber studding carrying the plaster-board finish. The steel stanchions carry heavy timber trusses, but, as in the majority of the other buildings, the structure is hidden in the finishes. An exception to this rule is the Women's Pavilion, in which the roof trusses of the Fashion Hall are boldly exposed. The pavilions of Ireland and Australia complete the Dominions Avenue. The



A, ¾in. spray jet; B, 200-watt submersible reflector (white); C, six 100-watt lamps (white); D, twelve 100-watt lamps (white); E, submersible cable holders; F, eighteen 100-watt lamps (white); G, six ¾in. spade jets; H, individual control cocks; I, 5in. main feed pipe; J, six submersible projectors, each with four 100-watt lamps (white); K, sixteen 500-watt submersible projectors, four per colour (red, amber, green, blue); L, eight 500-watt submersible projectors (white); M, cable joint box.

ARRANGEMENT OF FLARE FOUNTAINS IN THE LAKE

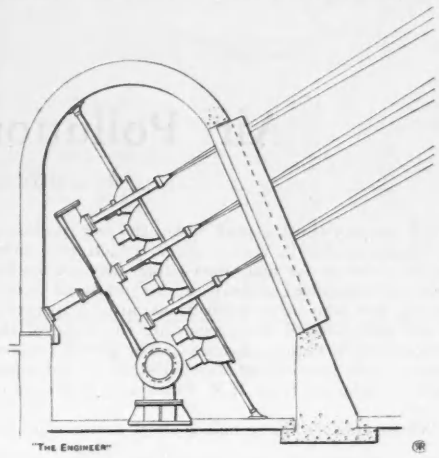
Australian Pavilion has a steel pitched roof and frame masked by high timber stud work, while the Irish Pavilion has a timber frame and lattice trusses.

Facing the Dominions Pavilions are the Colonial buildings, all of which have timber frameworks. The most interesting point in their construction is the queen post trussed beams carrying the first floor terrace over the cinema in the Empire Tea Pavilion. The three steel rods are left exposed and provide the requisite stiffness without the appearance of heaviness. The beams carry some 300 square feet of public space and are designed on the usual assumptions of combined truss and beam stresses. Some of the scantling employed in other pavilions is of interest; for instance, the British Railways Pavilion has 16in. by 3in., some 40ft. long; the Garden Club has 14in. by 6in., over 30ft. long; and the Atlantic Restaurant has its floor spanning the roadway with 14in. by 3½in. floor joists. Other large buildings, such as that of Industry, Shipping, and Travel, are also of timber construction, the roof in this case being of the Belfast pattern, the top member of which is carried up on web members to form a horizontal flat roof, the bow still being retained in the web. Similar construction was employed in the Agriculture Pavilion, and various other smaller pavilions have lattice, Belfast, or other wood trusses.

The buildings in the Amusement Park are almost universally of timber, even including the scenic railway, which is constructed of a light thoroughly triangulated framework.

In view of the variation in detailing, a good opportunity for research seems to be presented at the completion of the use of the buildings by a series of tests on these full-scale models.

The chief interest to the visitor will probably be the water displays. In connection with these displays credit must be given to the Edison Swan Electric Company, Ltd., and to the engineers, who have so ably carried out the technical side of the architect's



Twenty-four 1000-watt projectors with a 40–60 deg. beam spread in conjunction with 1in. fire nozzles.

FAN JET PROJECTION CHAMBER

designs. Messrs. Crouch and Hogg and Mr. Campbell Murray were respectively in charge of the civil engineering and the electrical work.

The largest single piece in these displays is the lake, which is 412ft. by 52ft., and is about 2ft. 6in deep. The display consists of twelve parabolic jets throwing a 100ft. arc from the western end of the lake over and on to a circular raised pool, in the centre of which is placed a statue and around which play further jets. Two four-tiered vase fountains, 16ft. high, of graduated moulded metal cones, and eighteen smaller "Christmas tree" fountains at 30ft. intervals, carry the interest to the furthest end of the lake. The main parabolic jets have projected along their axes concealed coloured floodlights, and also a further bank playing on the "breaking" end of the arc. Each group of fountain jets has a set of coloured floodlights, by various combinations of which striking effects are obtained. The lake is constructed of lightly reinforced concrete, with the construction joints formed over stiffener beams, reinforced against leakage by copper strips and bitumen. The intricate series of displays requires four separate sets of piping, and some idea of the size of the installation can be obtained from the motor horse-power provided, the total being close on 300 H.P. The circulation of 10,870 gallons per minute would have caused a noticeable eddy if the consulting engineers had not arranged it to take place under the curved weir overflow of the elevated pool.

The next largest display is the North Cascade, opposite the Paisley-road entrance. The cascade consists of three main tiers, falling a total of 75ft. Each tier is marked by its own pylon statue and semi-circular pool. The water plays as jets on the surface and falls in five steps, in each tier to the final basin. Each step has a weir of corrugated curved glass with reflectors, and coloured flood lamps. The lamps are controlled to give cycles of colour effects every five seconds, with a repeat cycle every 12 minutes. The South Cascade facing Moss Park-boulevard is similar, but has only one main tier, which is, however, somewhat larger than those of the north. The North or Royal Fountain is axial with the cascade and the Paisley-road entrance. The basin, over 50ft. in diameter, is constructed in 5in. reinforced concrete, and acts as a reservoir to the water of the cascade, which flows under gravity. The piping is elaborate, four 10in. lines being required for the displays. "Organ pipes," cruciform in plan, rise at the rim of the fountain to 20ft. and decrease evenly towards the centre to 5ft. There is also a

similar but reversed display. These displays require fifty-five and fifty-seven 1in. diameter nozzles. Other effects, such as the "water dome," "the crown," the "skyscraper," and the dispersers, can be combined and each requires 2500 gallons per minute. The various water effects last half a minute and are combined with a lighting change every five seconds, the whole scheme repeating every twenty minutes.

The South Fountain stands in the forecourt of the Palace of Engineering, and has a basin 26ft. in diameter, containing the inner basins of the display. This display consists of three rings rising to different heights up to 30ft., the water flowing to the outer basin over curved weirs. The colour lighting provides the change in this display, the water being "fixed." Enhancement of the colour lighting of the water, and also the milky daytime appearance of the displays is obtained by the aeration of the water. After considerable experiment, the engineers evolved nozzles which by induction produced the high refractive value required, and also enabled the production of a solid rod of water of 20 per cent. greater height.

The water displays when in full operation circulate about 22,000 gallons of water, and are operated from four pumping stations situated close to the displays and well concealed. These stations are largely underground, and are built of brick with concrete floors and timber joist and steel beam roofs. Heavy rain causing moisture penetration has not, however, interfered with the working. In each are contained the pumps, motors, and switchgear of the display, and also the elaborate and fascinating system of cams, excentrics, and ratchets operating through hydraulic valves and the "musical box"-like rotating drum contact switches of the lighting series. It seems a great pity that such ingenious and well-made mechanism should be scrapped at the end of six months.

The water supply to this temporary town, with its artificial waterfalls and fountains, is carried in some 3 miles of water piping, varying from 12in. spun iron down to 3in., some of which is in asbestos pressure piping.

The mains tap alternative sources of supply, and are formed into a ring. Boosters are introduced to deal with the daytime drop in pressure to 20 lb. per square inch, and special booster plant deals with the Tower and Tree Top Restaurant. It is of interest to note that the fire-fighting requirements settled the size of the mains—not the human consumption—and fire hydrants are installed at 100-yard intervals on the main pipes.

In addition to the lighting of the interior of the buildings and the water displays, floodlights are placed among the trees and on all the main buildings, including the Tower, and also on the flagpoles. The Tower has, in addition, special lighting on the balconies, and the majority of buildings and the pylons have neon strips. These systems are fed by ten subsidiary sub-stations.

(To be continued.)

Air Pollution in 1936-37.

By THOMAS McLACHLAN.

THE twenty-third report upon the air pollution observations in this country, which was published a few weeks ago, shows that fifty-six bodies (fifty-one municipal authorities, one industrial undertaking, and four other institutions) are co-operating in the collection of data regarding the state of the atmosphere in various districts. The period covered relates to the year ending March 31st, 1937, and copies may be obtained from H.M. Stationery Office, price 7s. 6d.

Whilst another thirty bodies assist in financing the collection and publication of these data, it was remarked last year that, even assuming that the present methods which are being employed are the most satisfactory, one can hardly obtain an accurate view of the state of the pollution which is occurring in various parts of the country. At the same time, it is pleasant to record that whilst the number of participants in this work has not increased considerably, the total amount of work being carried out is appreciably more than last year. This difference is shown chiefly in the number of deposit gauges exposed, the number for the year 1935–36 being 115; whereas for the year under review the number has grown to 133. Particular credit is due to the London County Council for installing gauges at Godalming and Rustington, whereby observations are now made at a seaside and a country district. Instruments have recently been installed at Lymington and Totton in Hants, but exactly which types the report does not state. It would be a considerable advantage if still more observations were to be taken in country districts. Although the Leicester survey was placed in hand during the year, no results are so far recorded, and these will be looked for with great interest.

TABLE I.—*Comparative Figures for the Total Collection of Solid Matter in Forty-two Towns and Cities of the United Kingdom During the Twelve Months Ending March 31st, 1937.*

City or town.	No. of Gauges.	Tons per square mile per annum. Total solids.	Sulphur as SO_3.
Group 1, Under 200 Tons.			
Loggerheads	1	63·65	8·80
Godalming	1	83·55	14·65
Rothamsted	1	95·28	—
Marple	1	109·80	19·78
Southport	1	114·50	13·88
Wolverhampton	1	126·50	17·30
Walsall	1	136·85	16·50
Bournville	2	144·80	16·01
Garston	1	156·93	20·75
Gloucester	1	162·68	—
Loughborough	1	162·93	—
Kingston-upon-Hull	3	170·38	26·66
Huddersfield	2	178·46	24·51
Southampton	1	178·55	16·65
Cardiff	1	179·35	21·58
Edinburgh	4	192·81	17·59
Wallsend	1	197·83	21·10
Total and averages	24	144·40	18·27
Group 2, 200 to 300 Tons.			
Halifax	4	203·15	27·68
Coventry	3	203·64	26·21
Shipley	1	214·68	22·45
Bristol	2	219·08	23·30
Wakefield	2	220·28	14·24
Sheffield	4	230·63	24·86
Bradford	2	232·01	28·50
Ashington	1	236·95	33·40
Burnley	4	240·93	29·55
Leeds	3	245·15	21·28
London	14	249·03	31·65
Leicester	3	252·81	24·16
Stoke-on-Trent	3	255·22	26·31
Newcastle-upon-Tyne	3	255·93	31·44
Glasgow	11	264·04	31·97
Pontefract	1	267·60	19·30
Dewsbury	4	279·71	27·29
Rotherham	2	281·68	28·38
Liverpool	3	293·62	22·54
Total and averages	70	244·53	26·03
Group 3, 300 Tons and Over.			
Salford	2	302·66	33·86
Castleford	1	351·20	34·23
Birmingham	2	373·63	—
Widnes	2	385·73	49·54
St. Helens	1	449·95	24·35
Hove	1	456·08	72·33
Total and averages	9	386·54	42·86

Table I contains the detailed figures of the London observations for the total solids and sulphur impurities for the five years ending March 31st, 1937, arranged in two groups, which represent more or less those in the eastern and western districts.

In calculating the averages the figures from Golden-lane and Ravenscourt Park have been omitted. One is again struck by the difference in the figures for the two groups, but it has to be remembered that there are no stations in the eastern group comparable to Kew, South Kensington, and Wandsworth Common. At the same time the prevailing winds do come from the south-west and this is reflected to some extent in the heavier deposits in the eastern section of London. The effect of position is noticed very definitely in the case of the four stations at Mount-street, Horseferry-road, Archbishop's Park, and Golden-lane, which are not really very far apart, and where the total deposit and sulphur in the gauges increases rapidly in this order. These may be compared with Victoria Park and Southwark Park. Victoria Park is only slightly north-east of Golden-lane and immediately north-east of the congested area of Shoreditch and Bethnal Green, and it is observed that the sulphur deposit is very considerably below that of Golden-lane, even if the years 1933–35 be omitted and the year 1935–36 be included. Southwark Park, on the other hand, is situated by the Surrey Docks, where steamboats are accused of discharging large quantities of smoke into the air, and immediately north of the gasworks in Old Kent-road, which are reputed to emit large quantities of sulphur fumes. The variation in these figures can only be accounted for on the assumption that the sulphur deposit consists partly of powder from the erection or destruction of buildings. It is to be regretted that lead peroxide cylinders are not exposed at all these stations, but if the results on the two stations at Mount-street and Horseferry-road are compared, it is noticed that whilst the deposit gauge at Horseferry-road shows a higher sulphur deposit than the one at Mount-street, the lead peroxide cylinder at Mount-street shows a greater amount of active sulphur dioxide than the one at Horseferry-road. In discussing the amounts of sulphur dioxide in the atmosphere, it is interesting to note that the lead peroxide cylinder at London County Hall records nearly twice the amount found at Horseferry-road, and, in conjunction with last year's figures, 1·7 times that at Westminster City Hall, whereas the volumetric method shows only a slightly higher figure at County Hall than at the City Hall, showing that a considerable amount of work will have to be carried out to discover how the results should be interpreted. In this connection it is to be observed that the Committee has given some thought to the suggestion put forward by Mr. McLachlan (the author) that micro-organisms might affect the results of the sulphur determinations in the rain-water gauges, and note that the further results of Mr. McLachlan and of Mr. Tankard and

TABLE II.—*The Total Deposit of Solid Matters and Sulphur Collected in the London Gauges During the Five Separate Years, 1933–34–35–36–37.*

Solid Matters.

Tons of solid deposit per square mile per annum.

East and Central Districts:	1932–1933.	1933–1934.	1934–1935.	1935–1936.	1936–1937.
Golden-lane	344	644	536	292	261
Archbishop's Park	331	346	407	435	322
Horseferry-road	327	399	322	344	480
Southwark Park	234	243	217	258	241
Finsbury Park	233	376	390	405	273
Victoria Park	208	226	224	224	209
Averages for 5 gauges	267	318	312	333	305
West and South-West Districts:					
Ravenscourt Park	472	—	242	293	210
Mount-street	291	270	262	293	314
Westminster	283	226	226	364	294
South Kensington (M.O.)	192	191	259	228	219
Wandsworth Common	163	179	154	183	172
Kew Observatory (S.)	134	120	123	131	128
Kew Observatory (N.)	115	116	114	125	117
Averages for 6 gauges	196	184	189	224	207

Sulphur.

Tons of sulphur as SO_3 per square mile per annum.

East and Central Districts:	1932–1933.	1933–1934.	1934–1935.	1935–1936.	1936–1937.
Golden-lane	46	110	100	38	39
Archbishop's Park	42	38	44	46	43
Horseferry-road	29	42	28	33	44
Southwark Park	28	31	24	35	24
Finsbury Park	28	63	89	99	27
Victoria Park	28	23	24	30	21
Averages for 5 gauges	31	39	42	49	32
West and South-West Districts:					
Ravenscourt Park	107	—	64	48	32
Mount-street	39	21	23	30	36
Wandsworth Common	26	23	23	25	22
Westminster	23	20	17	24	23
South Kensington (M.O.)	23	26	31	32	27
Kew Observatory (S.)	18	18	18	21	20
Kew Observatory (N.)	16	17	15	20	17
Averages for 6 gauges	24	21	21	25	24

TABLE III.—*Comparative Amounts of Sulphur Collected by the Gauges in Nine Towns and Cities During the Five Separate Years Ending March, 1937.*

Town or city.	Tons of sulphur as SO_3 per square mile per annum. 1932–1933.	1933–1934.	1934–1935.	1935–1936.	1936–1937.
Southport	14·2	10·8	13·6	14·7	13·9
Bournville (Works)	17·1	12·2	17·7	16·8	16·5
Birmingham (Central)	—	19·3	22·9	48·9	—
Glasgow	32·5	27·4	37·6	30·5	32·0
London	41·3	29·5	38·4	36·7	31·7
Leeds (Park-square)	34·3	24·5	25·4	31·0	30·3
St. Helens	38·9	32·8	30·9	31·2	24·4
London (Ravenscourt Park)	107·0	—	63·9	47·8	32·5
Hove	—	—	—	—	72·3

THE LONDON RESULTS.

Mr. Shelbourn do not show any significant alteration. The author has now been examining the deposits in gauges at two different stations, at each of which two gauges have been exposed, and he is reluctantly forced to the conclusion that the accuracy of the gauge method is such that in any case it would be impossible to detect any appreciable difference and that any attempt to do so will have to be made by other means. It does appear, however, that the deposit gauges probably give a more or less accurate record of total atmospheric pollution from all sources, that the volumetric method gives an indication of sulphur dioxide in a volume of the atmosphere, and, in the author's opinion, the lead peroxide method gives an indication of oxidisable sulphur dioxide and possibly other sulphur bodies impinging on a given surface for a given time. That there will be a considerable difference between the amount of sulphur dioxide measured by these two methods will be appreciated when it is remarked that the lead peroxide cylinder at Westminster City Hall is rather sheltered, whereas those at Mount-street, Horseferry-road, and County Hall are exposed. The pollution determined by the deposit gauge method is very largely affected by building and similar operations, and it must be due to this cause that the deposit gauge at Ravenscourt Park shows such high figures in a portion of London where there should be very little atmospheric pollution due to the combustion of coal, as compared with the more central portions.

For comparison Tables III and IV have been prepared to show in the former comparative figures relating to the amounts of sulphur collected in the deposit gauges of nine towns and cities during the last five years, and, separately, that at Ravenscourt Park, and in the latter the amounts of sulphur as determined by the volumetric and lead peroxide methods.

It is to be hoped that when the results of a few years' research at Leicester are available, it may be possible to place a more definite interpretation on the various figures, which are at present being accumulated, but it may again be urged that, whilst it is extremely difficult to see any real daylight in the mass of material which is thus being collected, it is because we need sun and daylight in our towns that more work on atmospheric pollution should be carried out, and that all those who are in any way responsible should be urged to keep any and every type of pollution to a minimum.

TABLE IV.—*Comparative Amounts of Sulphur as Measured by the Hydrogen Peroxide and Lead Peroxide Methods for Eleven Stations.*

Town or city.	Volumetric method. Volumes of SO_3 per million volumes of air.					Lead peroxide. Milligrammes of SO_3 per 100 sq. cm. per day.	Ratio.
	1932–33.	1933–34.	1934–35.	1935–36.	1936–37.		
Glasgow	—	—	—	0·084	0·096	2·65	1 : 28
Cardiff	0·035	0·044	—	—	—	1·96	—
Kingston-upon-Hull	—	0·079	0·060	0·063	0·063	2·72	1 : 43
Leicester	—	—	—	0·086	0·078	1·78	1 : 23
London :							
Chelsea	—	—	0·105	0·124	0·090	3·97	1 : 44
Westminster Bridge	0·157	0·154	0·160	0·154	0·123	5·60	1 : 46
Westminster City Hall	0·135	0·136	0·120	0·139	0·115	3·41	1 : 30
Royal Observatory, Greenwich	—	—	—	0·044	0·056	—	—
Newcastle	0·194	0·194	0·16	0·114	0·111	3·21	1 : 28
Salford	0·137	0·17	0·15	0·082	0·055	4·65	1 : 85
Sheffield	0·135	0·15	0·136	0·139	0·148	2·07	1 : 14

Failure of the Hasselt Welded Bridge.

ON March 14th, 1938, a serious accident occurred at Hasselt, Belgium, which happily only involved material damage and resulted in no personal injury. An entirely welded Vierendeel bridge, with a span of 74 m. 52 and a weight of 646 metric tons, over the Albert Canal, on the road from Hasselt to Genck, collapsed, after a series of fractures of its members. Just as two tramcars coupled together were about to cross the bridge the first fracture occurred, according to eye-witnesses, in the lower member of one of the main Vierendeel girders; during a period of six minutes, from 8.20 to 8.26 a.m., other members, overstrained by the first fracture, broke, finally causing the complete collapse of the bridge. The bridge had been in service for a year and a half, and was subjected, with successful results, on January 19th, 1937, to the regulation test loads of the national administration for bridges and roads.

In the line engraving reproduced herewith, due to the *Annales de l'Institut technique du Bâtiment et des Travaux publics*, are shown the probable successive phases of the accident. At F is shown the first crack in the lower member of one of the main girders. The roller support for the moving end of the bridge is indicated at A; at C is shown the fracture of the lower members, while at D is shown the top of the Hasselt abutment being chiselled by the end of the bridge. In the half-tone engraving is shown the final state of the bridge.

In the following article we quote the views of Professor E. François, of the University of Brussels, on the possible causes and consequences of the accident, as set forth in the May issue of *L'Ossature Métallique*, the review published by le Centre Belgo-Luxembourgeois d'Information de l'Acier.

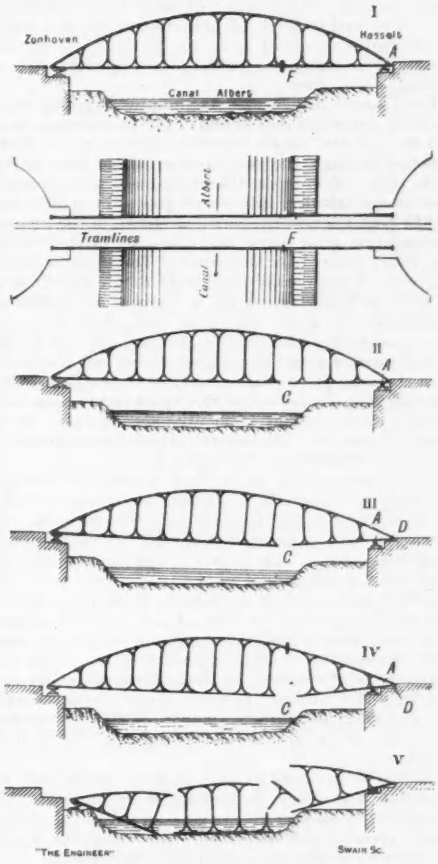
The collapse of the Hasselt bridge, according to Professor François, will rank amongst the memorable accidents to such structures. In the memory of man, such an abrupt failure of a metal bridge in service has not been heard of. The safety of steel bridges has been accepted as a certainty, but in this accident there occurred a sudden fracture which recalls the queer and unpredictable character of the fractures of brittle castings.

After its collapse, the Hasselt bridge was for some days a place of pilgrimage, where Belgian and other engineers gathered in great numbers. The majority of mankind is deaf to the signs and portents which oppose its immediate reasoning, and a catastrophe is necessary before it will admit in the end the reality of the situation. In the many provinces of engineering there have necessarily been accidents, resulting in the end in keeping new developments on a sound course. If composure is kept, the lessons which are to be learnt from the collapse of the Hasselt bridge, far from hindering the development of welded construction, will, on the contrary, contribute greatly to the progress of this recent development.

HASSELT WELDED BRIDGE AFTER ITS COLLAPSE

From 1933 to 1938, no fewer than fifty-two Vierendeel welded bridges, with spans varying from 60 m. to 90 m., were built in Belgium by about a dozen different firms of structural engineers, in mild and semi-mild steel, produced by the Thomas process by makers in all parts of Belgium and Luxembourg. These bridges were welded with three kinds of electrodes—"Arcos," "Esab," and "Thermarc."

It might have been wiser to have waited until the first bridges of this type had had time to reveal in full their weaknesses, but this kind of rapid development is not unusual; engineers often follow a practice which is established in an unknown manner. They also frequently give their thoughts a free rein in furnishing the explanation of an accident in a manner to suit their own fancies. One engineer will say that it is sabotage, or an outrage. Another will say that it is the earth return circuit of the nearby electricity supply cables which has caused the collapse of the bridge. It was the shrinkage of the reinforced concrete floor joints, a third will say. Temperature effects played a great part, will say a fourth person, for the accident took place at 8.20 in the morning and all the cracks which have occurred on other bridges, in or near the welds, likewise happened early in the morning. The bridge was not supported sufficiently during erection by means of two intermediate timber staging piers, a fifth will say. Yet another will say that the welding gang was at fault by reason of lack of honesty or skill.



SUCCESSIVE PHASES OF THE FAILURE

In most Vierendeel welded bridges the members are composed of very deep Grey girders. These large girders have, in certain cases, given signs of a certain weakness, no doubt because of the presence of internal stresses in the laminations of the web. The webs of deep Grey girders have been known to crack for a distance of 1 m. or 2 m. on exposure to an extremely low temperature or on suddenly unloading the structure. If the members of the Hasselt bridge had been constructed of Grey girders, they would certainly have been blamed, but wrongly, for the members were actually made from flanges welded to a solid web. In the Hasselt bridge the framework was made of girders from 1 m. to 1 m. 20 in depth, and the thickest flanges—from 45 mm. to 55 mm. thick—were welded to the web with angle strips. Welded girders with a solid web of this kind have shown themselves to be more and more dangerous as the thickness of the flanges increases—precisely the case in the Hasselt bridge. A step forward has been made by adopting a channelled section for the flanges and using a butt weld for the connection between flange and web; in this way the depth shrinks to the extent of a few millimetres and the internal stresses are thus partially relieved.

Numerous sudden fractures, accompanied by detonations, have occurred on other Vierendeel welded bridges; these sudden cracks manifest themselves for the most part at the works, although some occur during erection, indifferently at the weld, at the scarf of the weld, or in the solid plate away from the weld. The most serious of such cases of cracking was that of the Stockroye bridge in October, 1936.

There have also been noted, in the course of erection, deformations which have all been attributed to the existence of alarming shrinkage phenomena. For example, after making the last erection joint of a welded Vierendeel bridge which was still supported on two falsework piers, the end of the bridge lifted some 3 cm. This sort of information, when brought to many people's notice, causes criticisms to be made, which, after an accident has occurred, appear to be a form of prophecy.

There exist numerous welded frames which are successful, but they are always light triangulated structures, which look like lace-work and which can be readily deformed, thus minimising the residual stresses in the welds. In a period of eighteen years, from 1920 to 1938, a single Belgian firm has manufactured 20,000 metric tons of welded framework including the structure at Evere aerodrome, with a span of 66 m., and the wireless masts at Velthen, with a height of 100 m.

Welded Vierendeel bridges, by reason of their rigidity, are very susceptible to imperfections in design and execution. Residual stresses exist which make them susceptible to external influences of a minor nature, such as the shock arising from the fall of a body or from the passage of a train over a fish-plated rail joint on sleepers without ballast, vibration, heat, cold, and so forth. These bridges are in a state of internal stress and seem to be liable to almost spontaneous cracking; some have cracked like a casting or like glass.

The Hasselt bridge was six minutes in collapsing; after the lower member of one of the two main girders had broken the upper member, acting like a bow, chiselled through the two abutments and then broke in its turn. Thereupon the other main girder broke. The bridge divided into three parts, of which the middle part fell into the canal, as shown in the accompanying half-tone engraving. No part of the bridge was bent, twisted, or deformed. The cross sections where the fractures occurred were rough and showed no trace of being torn apart, or signs of elongation or contraction of area. In other places—in the two main girders and also the uprights, even in the welds, in the scarf of a weld or elsewhere beyond the weld, or in the solid plate—there could be seen sharp cracks showing a predisposition of the metal to previous hair cracks, which spread suddenly, accompanied by a noise. It was also obvious that there was a complete absence of ductility in the metal mass.

The construction of welded Vierendeel bridges demands an especially extensive knowledge of the art of welding and a strict adherence to its rules. In the first place, a metal is necessary which possesses weldability to a high degree; test results on the unstressed metal cannot give an assurance as to the practical and sufficient weldability in such a complex and rigid framework as that of a Vierendeel bridge. With the Hasselt bridge the amount of intense local heat applied for welding altered and coarsened the structure of the metal, so that it became short and brittle. The Thomas process, given certain simple and practical precautions, enables steels to be manufactured which are perfectly suitable for welded structures.

It is also necessary to have no more welds than are essential, for every redundant weld increases the danger from unrelieved stresses and from alteration in the structure of the metal. No endeavour should be made to amplify the safety of welded joints.

A careful preparation of the parts to be assembled on the site should be demanded; it is necessary that the sections which are to be welded should correspond exactly. Any inaccuracy in the relative adjustment of the parts leads to a useless weld, lacking uniformity with the other welds.

In the case of angle welds the use of very thick plates should be avoided; better still, channelled flanges should be used, which enable butt welds to be effected.

A general welding scheme should be made out, together with detailed schemes for the welding of each assembly. The details should be studied and the operations written out for the welding of each element of the joint, also for the sequence of welding the joints in the one assembly and the order of welding successive assemblies. The order adopted should compensate more or less for the shrinkage stresses and should give the residual stresses as far as possible opposite signs to the fatigue stresses produced by the loading.

Finally, the inevitable residual stresses should be calculated and allowance made for them.

Perhaps it would not be impossible to make the manufacturer undertake to reheat the most troublesome components of the assembly before incorporating them in the whole structure.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

TORSIONAL VIBRATION ANALYSIS BY MODELS.

SIR,—There are two further interesting ways of analysing torsional vibrations experimentally, namely, by means of "dynamically similar" torsional and axial models.

An actual system comprising three mass-moments of inertia, I_1 distant B from I_2, and I_3 distant D from I_2, mounted on an elastic shaft of torsional stiffness N J per unit length, has unknown lower and upper torsional frequencies F_1 and F_2 respectively.

This system can be replaced by a dynamically similar model three-mass torsional system comprising mass-moments of inertia i_1 distant b from i_2, and i_3 distant d from i_2 on a shaft of stiffness $n\,j$.

The mass and length ratios, u and v necessary for dynamical similarity between model and prototype, are matters of choice—

$$u = i_1/I_1 = i_2/I_2 = i_3/I_3 \quad . \quad . \quad . \quad . \quad (1)$$

$$v = b/B = d/D \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The model can be thrown into resonance in various ways by torsional impulses of measurable frequency. Let f_1 and f_2 be the lower and upper measured resonance frequencies for the model, then F_1 and F_2 are given by

$$F_1 = f_1\sqrt{\{(N\,J\,u\,v)/(n\,j)\}} = w f_1 \quad . \quad . \quad . \quad (3)$$

$$F_2 = w f_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Again, the prototype can be studied by means of a model three-mass "axial" system in which a mass m_1 at distance β from a mass m_2 and a mass m_3 distant δ from m_2 are fixed to a shaft of cross-sectional area a and Young's modulus e. The mass and length ratios x and y in this case are

$$x = m_1/I_1 = m_2/I_2 = m_3/I_3 \quad . \quad . \quad (5)$$

$$y = \beta/B = \delta/D \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This system can be forced into axial vibrations of measurable lower and upper frequencies φ_1 and φ_2.

The lower and upper torsional frequencies of the prototype are found in this case from

$$F_1 = \varphi_1\sqrt{\{(N\,J\,x\,y)/(e\,a)\}} = z\,\varphi_1 \quad . \quad . \quad (7)$$

$$F_2 = z\,\varphi_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

G. G. MCDONALD.

Department of Civil Engineering and Mechanics,
The University, Glasgow,
27th May, 1938.

The French Technical Maritime Association.

THE Association Technique Martime et Aéronautique held its annual meeting in Paris last week, when Monsieur Max Bahon, honorary general director of the Suez Canal Company, who succeeded to the presidency of the Association, which had been occupied for several years by Monsieur Emmanuel Rousseau, presided over the first sitting. Monsieur Max Bahon followed the example of his predecessor by reviewing the progress of naval construction and aeronautics during the past year in different countries, and mentioned particularly the results obtained with the new French cruisers and battleships, which, he said, were highly encouraging. The accommodation and comfort provided for officers and men contributed largely to the efficient working of the ships. The papers that followed number twenty-seven, many of them interesting, though for the most part mathematical demonstrations of theories. The first paper was presented by Monsieur Brunet, engineer at the Ateliers et Chantiers de la Loire, who explained the principle of the gate of the construction dock at Saint-Nazaire, where the battleship "Jean-Bart" is now being built. Constructed at right angles to the Loire, the dock has reinforced concrete walls, the tops of which are 12·5 m. above low water level. Having a width of 120 m., the dock has a level of plus 3 m. for construction on one side and minus 8 m. for the bottom of the fitting-out canal on the other side. They are separated by a working gangway at a level of plus 4 m. with travelling portal crane. The dock is pumped full of water to float the completed hull over to the canal, and is then emptied to float the hull in the canal. At the end of the canal is a dock gate opening into the navigable channel of the Loire. The level of the canal is maintained by opening the gate at each half tide. Between filling the dock and floating a ship out, the gate is subjected to pressures of considerable magnitude on each side, which would have necessitated a massive and much wider gate if the usual principles and methods of construction had been employed. Monsieur Caquot therefore adopted the system of a half-cylindrical gate, the concave side of which could be turned towards the dock when being filled. The sides of the gate are turned outwards and bear against the edges of the walls to which they are practically locked by the pressure. The top of the gate for a third of its height is a simple half cylinder, but for the rest the half cylinder becomes a floating caisson, and Monsieur Brunet's paper gives the calculations which determined the form of the caisson. As the massive concrete walls on each side of the gate are built on an insufficiently stable foundation, they are reinforced by heavy steel tension bars passing from one side to the other in the concrete walls and the floor of the canal. Comparisons with other dock gates at Saint-Nazaire show that the new construction is less than a quarter the weight of an ordinary gate for equivalent service, even if it were possible to employ such a gate with the limited width available, and a part of the saving is attributed to the electric welding of the new gate.

Tests to determine the efficiencies of propellers for and aft were carried out with models by Monsieur Igonet, who tabulated results showing that a propeller in front of a ship does not give the benefit of the wake produced by a propeller at the stern and the wash at the bows offers resistance to the hull. When the model of a hull with propellers fore and aft was hauled, there was more resistance from the forward propeller than from that at the stern. There was a short discussion on the paper, during which it was remarked that it showed the futility of inventions of propellers at the ship's bows, except in special cases. Monsieur J. D'Acremont, chief engineer of the Forges et Aciéries de la Gironde, presented a paper explaining how factors relating to the propulsion of propellers had been plotted out in curves and combined in two graphs which would simplify calculations and would be of practical value on board ship or when information was wanted immediately without elaborate calculations. Monsieur H. Brillié, former chief engineer of the Compagnie Générale Transatlantique, who has given special attention to problems of lubrication, read a communication on the "running in" of bearings in the light of recent experiments, and concluded that much had yet to be learned concerning the precise influence of grinding and other methods of surface finish on metals, as well as the advantage of an electrolytic deposit of chromium, cobalt, or other metals on propeller blades, for example. It is doubtful, he said, whether a hand finish would give a satisfactory surface for fluid friction, and experiments recently carried out suggested that grinding with a thin graphite oil film under high pressure, followed by an electrolytic deposit of chromium on parts of the blades liable to pitting and erosion, appeared to offer a line of research.

A system of stabilising ships on a principle suggested by Monsieur W. L. Bazé is being developed by the Société pour la Stabilisation des Navires, and it was explained by Monsieur E. Parvillé, the company's consulting engineer. The principle consists in checking rolling by the reaction of water jets from each side of the ship. It was affirmed that the reaction was practically instantaneous. For each jet there is a tube having an angle of 45 deg. from the suction orifice in the hull near the bottom to the pump, and the tube then bends round to the vertical for discharge through the hull. Experiments have been carried out during the past five years to determine the hydraulic and mechanical factors involved in the system, and Monsieur Parvillé was able to offer a theory based upon the results obtained which he regarded as proving that the system was efficient for all types of ships. He claimed that the installation is cheaper, simpler, and occupies less space than any other stabilising equipment. These preliminary experiments have led to the construction of a model, having the proportions of a liner, which is now at Havre with a view to carrying out practical tests. It has a length of 10 m. and a beam of 1·6 m., and draws 70 cm. of water. It has two pumps on each side with the tubes longitudinal to the hull, and a complete equipment for measuring anti-rolling effects. Tests will be made of various forms of automatic control. There are so many problems involved that the tests are expected to occupy a considerable time. In the discussion on the paper there was no criticism of the principle of employing water jets to produce a stabilising effect, though it was remarked that the stabilising fins used in England gave equally good results, to which Monsieur Parvillé replied that the action of fins was slow, whereas the reaction of water jets was almost immediate.

SIXTY YEARS AGO.

IN our issue of June 21st, 1878, we recorded the death of Mr. Henry William Ferdinand Bolckow, at the age of seventy-two. He was born at Sulten, in Mechlenburg-Schwerin, and after being educated for a commercial career came to England in 1827. At first he was associated with the business of Mr. Christian Allhusen, of Newcastle-on-Tyne. In those days Middlesbrough was a hamlet. The rich Cleveland field was not unknown, but its full extent was not appreciated. The Messrs. Pease, however, had cast their eyes upon the spot. So, too, had Mr. John Vaughan, the manager of the Walker ironworks. In 1841 Bolckow and Vaughan, with a capital of £40,000, purchased a footing in the new field and began the erection of works for the manufacture of finished iron. In 1846 they established two blast-furnaces at Witton Park, and in 1850 Vaughan discovered the great "main seam" which had, all the time, been lying unnoticed beneath their feet. It was the start of the Cleveland iron trade. The partners immediately opened mines at Eston. In 1851 they erected three furnaces at Middlesbrough, and shortly afterwards six more at Eston. In 1865 the firm became Bolckow, Vaughan and Co., Ltd. By 1878 the company owned about a dozen collieries, besides iron mines in Spain, Portugal, and Africa. In 1868 Mr. Bolckow was naturalised by a special Act of Parliament. . . . In the same issue we illustrated the "very latest development" of Edison's phonograph. It consisted of a cylinder mounted on a screwed shaft which was rotated by a wound-up weight, the speed of rotation being rendered uniform by means of an air resistance governor. The cylinder was covered with a sheet of tin foil against which there bore an agate point fastened to a diaphragm fitted with a mouthpiece. The phonograph in this form was used both for recording and for reproducing sound. A double mouthpiece was provided for the purpose of recording duets. . . . Another article in the same issue described the method of making bent cranks developed by Mr. Edward Clarke at his works at Lincoln. The equipment employed consisted of hydraulic presses, but to-day the article is interesting less for its description of the machinery used than for its remarks concerning the merits of specialised production. Mr. Clarke established his works for the manufacture of bent cranks, and nothing else. When he did so, few believed that he would be successful on the ground that hitherto engineering works had been equipped for "general" manufacture, as distinct from the manufacture of "specialty" products. It was argued that Mr. Clarke would receive only the orders of a few small firms which could not afford to install crank-making plant for themselves. As it was, by confining his attention to one thing and by installing specialised plant for its manufacture, he was soon in a position to supply a large proportion of British firms with better and cheaper cranks than they could make in their own works.

THE LATE MR. HAROLD JOHNSON.—We regret to learn that Mr. Harold Johnson, a director of Steam Plant Accessories, Ltd., 82, Victoria-street, London, S.W.1, died on June 8th. His death occurred after a long and painful illness.

Rail and Road.

A PRIVATE LINE PURCHASED BY SWEDISH GOVERNMENT.—The Swedish Government is reported to have purchased for the State Railways the 74-kilom. long privately owned Landskrona, Lund, and Trälleborg Railway, at a cost of 1,250,000 kroner.

NEW RAILWAY IN CHINA.—It is reported that the Chinese Government and a group of French financiers have signed a contract for the construction of a railway from the border of French Indo-China to Nanning, in the Chinese province of Kwangsi. The new line, which will be about 120 miles long, will form an extension of the existing line from Hanoi to the frontier and will probably be built *viâ* Lungchow.

NEW BY-PASS ROAD IN WANDSWORTH.—The London County Council announces that the new Wandsworth by-pass, which is being constructed by the Council at an estimated cost of nearly £65,500, is nearing completion. This road forms a link between Putney Bridge-road and York-road, and is designed to relieve the congestion of traffic in Wandsworth High-street, which it is anticipated will be intensified on the opening of the new Wandsworth Bridge now in course of construction. The whole of the new road, which is about ¼ mile in length and 60ft. wide, will be completed in about a month's time. The scheme has involved the building of a new bridge over the river Wandle at a cost of about £11,250. All the works have been designed by the Council's Chief Engineer, who has also supervised the construction of the new bridge.

MARGATE ROAD SCHEME.—Extensive improvements to the Canterbury–Margate road between Birchington-square and Queens-road, Westgate, are proposed by the Margate Town Council, on whose application the Minister of Transport has made grants from the Road Fund towards the cost, which is estimated at nearly £60,000. The proposed improvements include the widening of the road, which at present averages 28ft. overall, to a minimum of 60ft., and the provision of a central carriageway, 30ft. wide, in place of the existing 22ft. carriageway. The overall width will be increased in certain places to dimensions varying from 60ft. to as much as 110ft., and some belts of trees will be left to form a central reservation between dual 20ft. carriageways. The total length of road covered by the scheme is 1¾ miles, of which rather more than ¼ mile will be equipped with the dual carriageways. It is expected that the work will take about nine months from the date of beginning work.

L.N.E.R. APPOINTMENTS.—The London and North-Eastern Railway Company announces that the following appointments have been made:—Mr. L. Hyde, works manager, Inverurie, to be works manager, Cowlairs; Mr. L. Farr, works manager, Cowlairs, to be works manager, Inverurie, in succession to Mr. Hyde; Mr. J. B. Dawson, district engineer's office, Sheffield, to be district engineer, Sheffield, in succession to Mr. L. V. Warhurst, who will retire from the service on June 15th; Mr. W. G. Dunstan, engineer's office, York, to be assistant district engineer, Ipswich. In consequence of the impending retirement of Mr. R. A. Thom, mechanical engineer, Southern Area, at the end of July next, the directors have also made the following appointments:—Mr. E. Thompson, mechanical engineer, North-Eastern Area, to be mechanical engineer, Southern Area, Western Section; Mr. A. H. Peppercorn, locomotive running superintendent, Southern Area, to be mechanical engineer, North-Eastern Area; Mr. F. W. Carr, assistant mechanical engineer, Stratford, to be mechanical engineer, Southern Area, Eastern Section.

MALTON BY-PASS SCHEME.—A grant has been made by the Minister of Transport towards the cost of constructing a by-pass round Malton on the York–Scarborough road. The by-pass, which will be about 4½ miles long, will cost about £213,000 to build. Beginning at Musley Bank Corner, it will curve around the north-west side of Malton, crossing the roads to Helmsley and Whitby (B.1257 and A.169) by means of traffic roundabouts. A traffic circus will also be constructed at Musley Bank Corner. Two new bridges will be necessary, one over the London and North-Eastern Railway Thirsk branch, and the other over the river Derwent. All bends will be banked and the lay-out of the road, as approved for the North Riding section, comprises one 30ft. central reservation, two 22ft. carriageways, two 6ft. verges between carriageways and cycle tracks, two 9ft. cycle tracks, two 3ft. verges between cycle tracks and footpaths, and two 5ft. footpaths. Although two footpaths are provided for, it is intended at this stage to construct only one. The North Riding section will be put in hand as soon as possession is obtained of the necessary land, and the scheme will probably be completed in a period of between two and three years.

HIGHWAY DEVELOPMENTS IN LINCOLN.—The Minister of Transport has approved in principle a highway development scheme for the centre of the city of Lincoln. The scheme, which is estimated to cost more than £200,000, covers the construction of a concrete viaduct over the London and North-Eastern and the London, Midland and Scottish Railways, with raised approaches; the reconstruction and widening of Magpie Bridge and the widening of Broadgate as far as St. Rumbold's-street; and the replacement of the privately-owned swing bridge over Brayford Lock by a fixed structure and the widening of approaches. The second of these three projects, estimated to cost about £35,000, has already been made the subject of a grant from the Road Fund, and it is expected that the work will be put in hand immediately. The traffic difficulties in Lincoln arise largely from the fact that vehicles on the main roads from the South are discharged into the High-street, where movement is restricted by two level crossings and also by the ancient monumental arch known as the Stonebow. It has been decided that the only satisfactory solution of the problem is to provide an alternative route for north-south traffic *viâ* Melville-street and Broadgate, which runs parallel with High-street. Access to this alternative route will be provided by means of the proposed viaduct over the railways. There will be two approaches to the viaduct from each side. Magpie Bridge is at present 20ft. wide and the proposed new structure will have a width of 64ft., carrying a 44ft. wide carriageway, and two 10ft. wide footpaths.

Miscellanea.

HYDRO-ELECTRIC POWER IN HYDERABAD.—Investigations have shown that the two big rivers flowing through the State of Hyderabad can be harnessed to produce 145,000 kW continuously, and the larger tributaries another 70,000 kW. A number of projects, costing a total of 650 million rupees, have been drawn up and the plans are for combined hydro-electric and irrigation schemes to be connected up in a complete grid scheme.

A TURKISH IRON AND STEEL PLANT.—In the report of the American Embassy at Ankara particulars are given of the new iron and steel plant at Karabuk, near Zafranbol, in Turkey, which when completed will have cost £T18,000,000. The works will consist of coke ovens, two blast-furnaces, steel works, rolling mill, pipe works, &c. The estimated daily consumption of raw material by the plant includes 1200 tons of iron ore, 220 tons of limestone, and 1300 tons of coal. About 600 tons of steel ingots will be produced daily. The by-products of the coke ovens will be benzol, ammonia and tar. It is estimated that the annual output of pipes and tubes will reach some 20,000 metric tons, and also that the output of the Karabuk plant will cover a large proportion of the requirements of the Turkish market.

VALUE OF OIL SHALES AND CANNELS.—In a paper at the Conference on Oil Shale and Cannel Coal at Glasgow, Messrs. R. A. Mott and C. E. Spooner said that, like coals, the oil-yielding capabilities of oil shales and cannels was dependent upon the hydrogen content of the organic matter they contained. The hydrogen content determination was difficult, and it was shown that the oil yield might be estimated from the volatile matter and the calorific value, or from the volatile matter alone if the oxygen content of the organic matter of an oil shale, cannel or coal was known. The authors went on to say that assuming that the oxygen content of the organic matter of an oil shale in one deposit remained constant, the volatile matter test might be used as a means of assessing variations in oil-yielding ability in different parts of the deposit.

SYMPOSIUM ON PLASTICS.—A recent publication of the American Society of Testing Materials deals with a symposium on plastics held at the Society's March regional meeting. Six papers were presented and these papers have been reprinted, together with the discussion which followed each one. The titles of the papers were:—"The Properties of an Ideal Plastic," by A. F. Randolph; "A Discussion of Testing Methods for the Determination and Comparison of the Strength Properties of Various Organic Plastics," by A. M. Richardson; "A Review of Methods for Measuring the Thermal Properties of Plastic Materials," by W. A. Zinzow; "Flow Relations of Thermoplastic Materials," by C. H. Penning and L. W. A. Meyer; "Hardness as Applied in the Plastic Industry," by J. C. Pitzer; and "Permanence in Plastics," by G. M. Kline.

PROPOSED JARROW STEEL WORKS.—In a letter to Mr. C. V. H. Vincent, the chairman of the Jarrow Division of the Conservative Association, the Parliamentary Secretary to the Board of Trade said that in so far as the arrangements made by the other interested parties had permitted, the Government had discharged all the responsibilities it undertook, to provide part of the capital on the loan, for the Commissioner of Special Areas to acquire the site and lease it to the new company, and for the Commissioner to provide assistance by way of contributions towards the rent, rates, and income tax. He did not think the Government could fairly be blamed if more rapid progress had not been made. Negotiations had been proceeding continuously between the parties concerned, and he hoped it would not be long before the company was able actually to start work on the site. The Prime Minister also wrote to Mr. Vincent and said that he hoped that before long the proposed steel works company would be in possession of the site.

GROWTH OF ALUMINIUM PRODUCTION.—An analysis of metal production during 1937, issued by the Aluminium Information Bureau, comparing the tonnages for 1937 with corresponding figures for 1924, shows that the production of aluminium and of nickel has increased threefold, while the production of gold has doubled. Much smaller increases are shown by other metals, copper having increased by 74 per cent., zinc by 66½ per cent., tin by 47 per cent., iron by 42½ per cent., lead by 33 per cent., and silver by only 6 per cent. There were 825 tons of aluminium produced in 1913, 2486 tons in 1924, and 5236 tons in 1937 for every million tons of iron produced in each of those years. In volume, there were produced 2400 cubic feet of aluminium in 1913, 7230 cubic feet in 1924, and 15,230 cubic feet in 1937 for every million cubic feet of iron produced. In 1913 there were 230,800 cubic feet of aluminium produced for every million cubic feet of lead, but in 1937 aluminium was produced in greater volume than lead, with 1,232,000 cubic feet to the million cubic feet of lead.

THE E. J. FOX MEDAL.—At the opening meeting of the thirty-fifth annual conference of the Institute of British Foundrymen, held in Bradford on June 15th, Mr. J. E. Hurst was presented with the E. J. Fox Gold Medal. This medal, given in 1936 to the Institute by Mr. E. J. Fox, managing director of the Stanton Ironworks Company, Ltd., is presented annually to a scientist who has in some outstanding way contributed to the advancement of foundry practice and metallurgy. The first award, made at last year's annual conference, was to Emeritus Professor Thomas Turner. Mr. Hurst, who is at present technical director of Bradley and Foster, Ltd., Bradley's Concrete, Ltd., of Darlaston, and of Sheepbridge Stokes Centrifugal Castings Company, Ltd., Chesterfield, is a member of the Institute of British Foundrymen, which he joined in 1914; a member of the Iron and Steel Institute, a Carnegie Research Scholar, and as Chairman of the Research Committee of the British Cast Iron Research Association, he is actively associated with the developments made by that Society. He also holds membership of the Verein Deutscher Giessereifachleute, the American Foundrymen's Association, the Sheffield Foundry Trades' Technical Society, and the Sheffield University Foundry Degree Course Advisory Committee. Mr. Hurst is also a Governor of the British Foundry School.

Air and Water.

SECOND SEA LORD.—It is announced that the King has approved the appointment of Admiral Sir Charles Little to be Lord Commissioner of the Admiralty and Chief of Naval Personnel in succession to Admiral Sir Martin Dunbar-Nasmith.

SHIP CASUALTY RETURNS FOR APRIL.—The Liverpool Underwriters' Association in its return for April, reports nine total and 466 ships partially lost during the month. These casualties refer to motor and steamships of 500 tons gross register and upwards.

NEW CANAL IN MOROCCO.—An irrigation canal, 15 miles long, which has taken nine years to build, has been declared open in Morocco. It links up with the river Dumer-Rabia, and is intended to irrigate some 60,000 acres of barren land at the foot of the Atlas Mountains.

SHIPPING EXHIBIT IN EDINBURGH MUSEUM.—A hall of shipping has been opened at the Royal Scottish Museum, Edinburgh, by Sir Maurice Denny. The new section contains a collection of more than one hundred models of ships covering the history of shipping from primitive craft to the period of the Great War.

NEW SHIP TANK IN AMERICA.—A new ship testing tank is rapidly nearing completion at Carderock, Maryland, in the United States. The new tank is over a quarter of a mile long and has four basins, one of which is 21ft. wide and 1000ft. long, and provision is being made to lengthen one basin to an ultimate length of 2500ft.

NEW MOTOR VESSEL FOR LAKE WINDERMERE.—The London, Midland and Scottish Railway Company's new motor vessel "Swan," built by Vickers-Armstrongs, Ltd., of Barrow-in-Furness, for service on lake Windermere, was launched at Lakeside on Friday, June 10th. She has accommodation for 800 passengers.

THE "AQUITANIA."—In a recent voyage from New York to Southampton, the Cunard White Star liner "Aquitania" steamed 590 miles in 23 hours, and equalled her record for the number of miles covered in one day on the eastbound run. On the outward trip the "Aquitania" eclipsed her best previous crossing by maintaining an average speed of 24·41 knots.

NEW NORWEGIAN SERVICE.—A new direct steamship line connecting Trondhjem and London will be opened when the rebuilding of Billingsgate fish market is completed, says a note in the *Journal of Commerce*. The line will be of great importance for the Norwegian export of fish, and the Norwegian Government therefore proposes, on certain conditions, a yearly subsidy up to £10,000 spread over six years.

THE MOTOR YACHT "BLUEBIRD."—At her trials on the Humber measured mile, the twin-screw motor yacht "Bluebird," built for Sir Malcolm Campbell by the Goole Shipbuilding and Repairing Company, Ltd., averaged a mean speed of over 11 knots. This yacht, which has a length of 95ft. between perpendiculars, is propelled by two five-cylinder vertical cold-starting 150 B.H.P. at 600 r.p.m. oil engines, made by Ruston and Hornsby, Ltd.

TRAMP SHIPPING.—The report of the Tramp Shipping Administrative Committee for the second half of last year says that co-operation in the industry without a subsidy is now proved possible by the adoption of a voluntary scheme. It is equally true that the conditions of co-operation attached to the subsidy during its currency gave it a value transcending its monetary value. But for those conditions, even the bare monetary value of the subsidy would most certainly have been dissipated and lost to the industry.

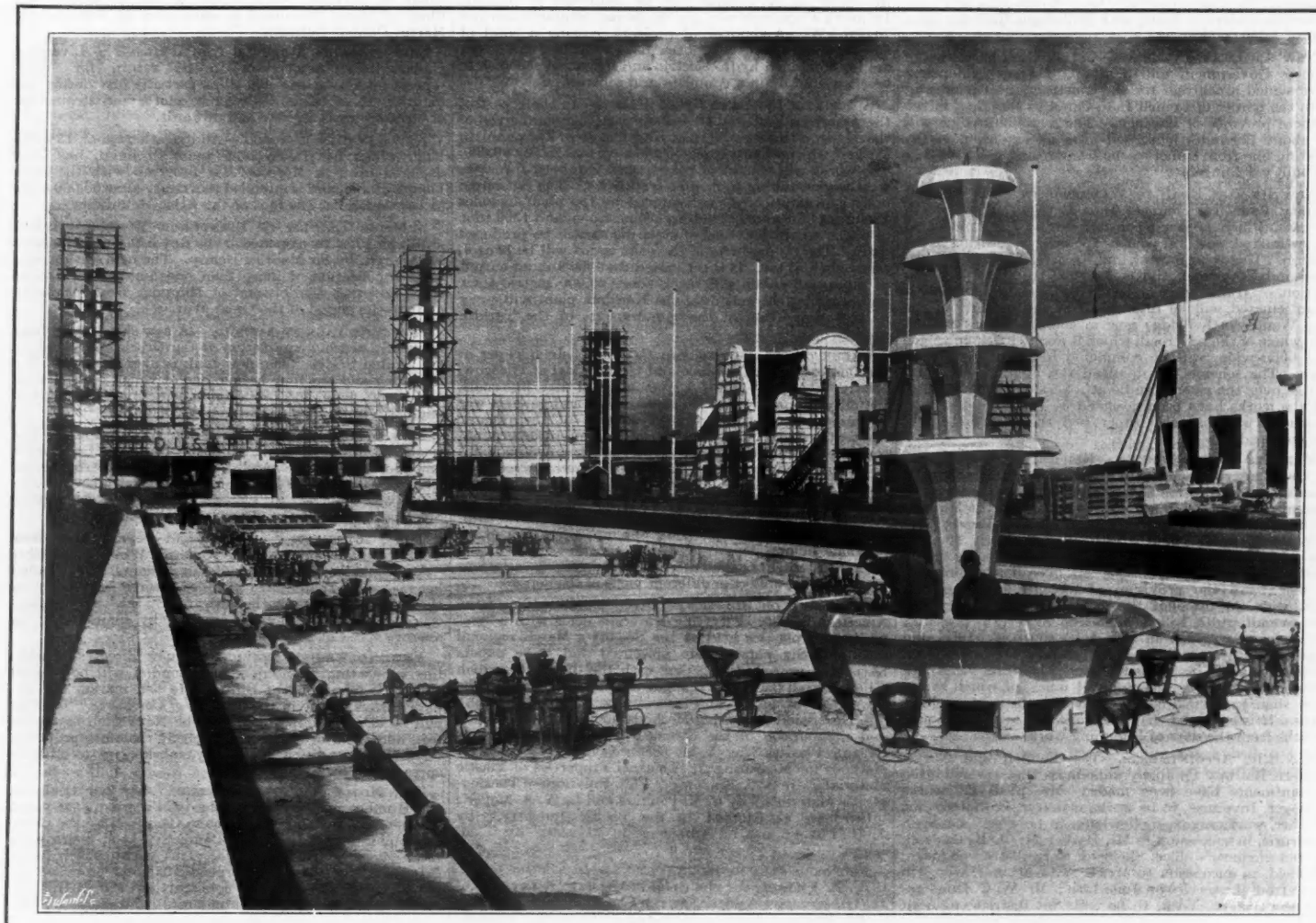
AUSTRALIAN AIR MAIL SERVICE.—It is announced by the Air Ministry that the last section of the new Empire flying-boat route between England and Australia will be inaugurated on July 2nd when the first Quantas Empire flying-boat leaves Singapore for Sydney, where it will arrive on July 5th. The service will be operated with Short "Empire" flying-boats, of the same type as those which are already in service as far as Singapore. In future the flying-boats of Imperial Airways and Quantas Empire Airways will thus be traversing the whole route between Southampton and Sydney.

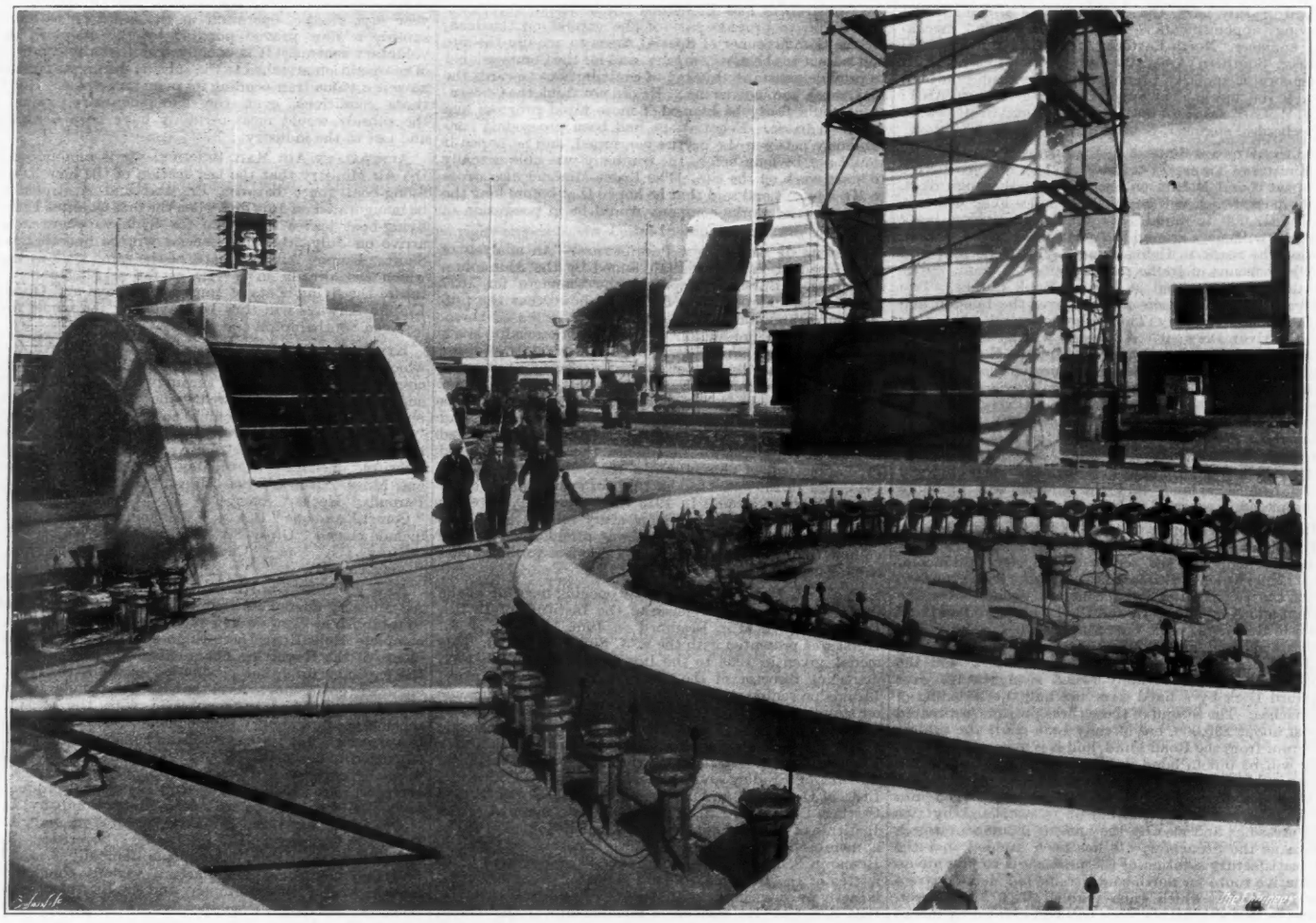
KING'S CUP AIR RACE.—For the King's Cup Air Race, which this year is being flown on July 2nd over a 50-mile circuit from Hatfield, with turning points at Buntingford and Barton Airport, twenty-one entries have been received. Among the machines entered are three Percival "Mew Gulls," two Percival "Gulls," one "Sparrowhawk," two Percival "Vega Gulls," three Comper "Swifts," one Miles "Hawk Major," one Miles "Monarch," one Miles "Hawk," one Miles "Hawk Trainer," two Parnall "Hecks," one C.W.A. "Cygnet," one D.H. "Comet," and one "B.A. 4." The engines of the machines include eleven "Gipsy Six," eight "Gipsy Major," three "Gipsy III," one "Cirrus Major," and one Pobjoy "Niagara III."

NEW FACTORY FOR ROLLS-ROYCE AERO-ENGINES.—The Air Ministry announces that the Air Council has decided to establish at Crewe a new factory for the production of complete Rolls-Royce aero-engines to meet the requirements of the Royal Air Force expansion and to increase the capacity for rapid production of Rolls-Royce aero-engines in emergency. As in the case of the similar factories already established in connection with the expansion scheme, the new factory will be financed and owned by the Government, but its operation and management will be entrusted to Rolls-Royce, Ltd. In addition to the firms normally engaged in the production of aero-engines, six companies are already engaged in the special production of aero-engines. These are Austin Motor Company, Ltd.; Rover Company, Ltd.; Standard Motor Company, Ltd.; Daimler Company, Ltd.; Rootes Securities, Ltd (Humbers); and Bristol Aeroplane Company, Ltd. The first five companies manufacture various components, and the Austin Motor Company and the Bristol Aeroplane Company assemble the engines and test them. Two companies, the Austin Motor Company, Ltd., and Rootes Securities, Ltd. (Humbers, &c.), are engaged in the manufacture of complete air frames and, in addition, special factories are producing air screws, carburetters, and magnesium.

THE GREAT LAKE AT THE EMPIRE EXHIBITION, GLASGOW

(*For description see page 669.*)





GENERAL VIEW OF SOUTH END SHOWING JETS AND PROJECTORS
MAIN JET PROJECTOR CHAMBER AND ADJOINING POOL

The Engineer

JUNE 17, 1938.

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NOTICES TO READERS.

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CHANGES OF ADDRESS.

**** Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Pencil Portrait, No. 17.

With this week's issue we present a Pencil Portrait of Sir Leonard Pearce, C.B.E., Engineer-in-Chief of the London Power Company. Sir Leonard was formerly an Electricity Commissioner and Consulting and Chief Engineer of the Manchester Corporation Electricity Department. He is a Member of the Institutions of Civil, Mechanical, and Electrical Engineers, and a Past-President of the Junior Institution of Engineers and of the Incorporated Municipal Electrical Association.

ARMAMENTS AND LABOUR.

ON June 9th the Confederation of the Shipbuilding and Engineering Unions met in York to consider a reply to the Employers' Federation on the question of the acceleration of the armaments programme. It reached no decision and the matter has been deferred until another meeting on July 6th. The reason given for the postponement is the desire of the Confederation, as expressed by Mr. E. Gilbert, secretary, "to get unanimity before we decide the policy." The bone of contention is the necessity for the relaxation of certain regulations and the dilution of labour. The Government desires to be in a position to use non-union labour if the necessity arises; the unions hold that dilution cannot be necessary and they are, at present, opposed to any relaxation of their "rights."

From the national point of view the position is very interesting and very delicate. And so it will remain as long as no emergency arises. But if emergency does arise the position will cease to be merely interesting and delicate; it will become dangerous. What it amounts to is this. The Government of the country, which alone is acquainted with all the needs, has come to the conclusion that circumstances may require that certain concessions and privileges allowed to trades unions be abrogated. The trades unions retort that they also have considered the conditions, that they do not agree that any modifications of the existing regulations are necessary, and that they are not prepared to endorse the foreign policy of the Government. The last statement was, perhaps, not made at the York meeting, but is deduced from the proceedings at other meetings and the speeches of some of the labour leaders inside and outside Parliament. It may be that at the renewed meeting on July 6th the constituents of the Confederation will agree, either unanimously or by a large majority, to place themselves entirely in the hands of the Government and will profess their willingness to waive their claims in the face of national necessity. Frankly, we suspect that they will do nothing of the kind. We anticipate that the Confederation will have no difficulty in demonstrating by statistics that there is more than a sufficiency of trade unionists to meet what it believes to be the requirements of the programme, and it will resist the engagement of non-unionists because it fears that the principles of unionism will thereby be undermined. That attitude will be perfectly reasonable and perfectly understandable. But, nevertheless, it is one that must cause anxiety. The essential issue is not what the Confederation thinks, but what the national Government thinks. It is beyond question that the Confederation, which represents, we believe, well over one million members through the thirty or more unions of which it is composed, would have the ability to stop or delay the rearmaments programme. The Government has no power that it could wield against it. If the constituents elect to say that means for the acceleration of the programme are distasteful to them, and that in no circumstances will they agree to concessions or tolerate dilution until every single unionist is employed, they have the means to enforce their will. We see no escape from that fact. Imagine the worst. Imagine that the Government insisted and that the federated unions called all the men out. It is well known that there is no force by which a strike can be broken. No doubt it would fail ultimately by attrition, but only after weeks of delay and misery, and almost certainly with the creation of a highly dangerous social condition. Such a state of affairs at the present moment would be intolerable and might be disastrous. The Government or the employers by whom the negotiations are being conducted must strive earnestly to do nothing that would provoke it.

Clear as this conclusion must have been from the first to all who have given thought to the matter, we draw attention to it not because we fear that a disastrous struggle is likely, but rather because we believe that although the unions have this power in their hands, they will not make use of it unless some gross indiscretion fires their animosity. An important point to remember is that the A.E.U. is not represented on the Confederation, and whilst its accession to the final decision of the Confederation is sought, we have no doubt that if a restraining influence is necessary it will provide it. We say this despite the fact that up to the present the A.E.U. has, amongst the unions, been the one most strongly opposed to the relaxation of its existing rules. But the principal grounds on which the hopes of a friendly agreement may be based are that the eleven million or so registered persons in the ranks of labour, to say nothing of a few more millions not covered by the insurance scheme, are as well aware as the rest of the inhabitants of the kingdom that the rearmanent programme is literally a vital necessity. They may hold on to their privileges to the last, as they are fully justified in doing, but we are certain that once they are convinced of the national need that they should suspend their restriction, they will do so; particularly if a binding guarantee that the *status quo* shall be resumed at the earliest moment can be drafted.

Welded Vierendeel Bridges.

ON another page in this issue we describe the failure of a comparatively recently erected welded steel bridge of the Vierendeel type. The bridge which failed spanned the Albert Canal, near Hasselt, in Belgium. It was built in 1936 and had been in service for about eighteen months. This design of bridge consists of bowstring girders with Vierendeel panels; that is to say, the panels consist of upright members only, and there are no diagonal members. More than fifty such bridges have been built in entirely welded construction in various parts of Belgium in recent years with spans ranging from 60 m. to 90 m. The sudden nature of the collapse of the structure, happening at a time when the engineers responsible for this type of construction had thought that their methods were protected by the experience gained in previous designs of welded structures, has naturally caused some doubt as to the wisdom of proceeding with further structures, and as to the safety or otherwise of the welded bridges already in existence. Although the particular failure under consideration caused no personal injury, the occurrence of such a disaster in a modern example of engineering practice, made in steel and fabricated after much patient research work in the art of welding, is bound to produce anxious discussion in interested circles.

Without prejudicing the conclusions of the official inquiry which is taking place, we think that the views of several engineers, in particular those of Professor Eugène François, of the University of Brussels, Vice-President of the Belgo-Luxemburg Steel Information Centre, who is a specialist in welding technique, may be discussed. Professor François stresses the importance of the welding methods used in such constructions. Unrelieved stresses in the metal, especially in the webs of deep built-up girders, are cumulative unless special precautions are taken against their occurrence. He points out that sudden cracks have been noted in many such structures; the cracks may occur at the weld or in the solid metal away from the weld, but they usually make their appearance during the assembly welding operations at the works. A Vierendeel bridge, by reason of the rigidity of its members, suffers in a greater degree from unrelieved internal stresses than the many existing successful structures composed of light triangulated frames, which are readily strained under the action of the internal stresses. According to Professor François, the examination of the fractures on the bridge showed that the metal throughout was brittle. He insists on the rigid adherence to a code of welding rules compiled by a responsible authority. First and foremost there must be used a metal which possesses weldability to a high degree, and which does not suffer coarsening by local heating effects. Perhaps one of the most important of his comments is that on the desirability of subjecting welded frames or portions thereof to a heat treatment for the release of internal stresses. Although the bridge did not fail at a particular weld, the consensus of opinion of the foreign welding specialists appears to be that the manner in which the work was carried out was primarily the cause of the failure. A note on the accident, published by the *Revue de la Soudure Autogène*, stated that engineers should not condemn the welding as such, but that they should direct attention to bad conditions of execution. Many firms which are expert in riveted construction believe themselves able to turn to welded construction without the necessity for taking into account conditions which are essentially different in the two forms of construction; if this is not the case, they shelter behind illusory and uncertain tests. Good welding depends on numerous factors, such as the weldability of the metal; the position of the welds; determination of the stresses and strains; preparation of the edges; and the methods of welding and erection. If each one of these factors is known, the assembly can be guaranteed, but if any one is not known precisely, a step is taken into the darkness, and whatever may be said to the contrary, inspection and tests after welding teach nothing that could not have been known before, except inferences—often erroneous—on the qualities of the assembly, which perhaps lead to the hiding of faulty work. In the same periodical, Monsieur H. Gerbeaux, head of research work at the French Institute of Welding, commenting on the cause of the bridge failure, states that the section which first fractured confirms that the erection welds were badly executed. The factory welds also showed signs of bad workmanship. Some of the fractures in the welds and in the solid metal showed portions which had been corroded prior to the occurrence of the accident, indicating former cracks. The cracks were numerous and local and they occurred without signs of elongation of the metal, giving evidence of the unsuitable quality of the steel used. The last-named factor can be judged to be largely responsible for this type of fracture. Monsieur Gerbeaux then goes on to enumerate the rules for successful welding. He adds that the Vierendeel bridge, which has been popular in Belgium for more than fifty years in its riveted

form, but for only a few years in welded form, should not be rejected by reason of the failure of the Hasselt bridge. It is the choice of the metal which should be condemned. This essential fact is the very one that is most neglected. The Hasselt bridge, like many others, was constructed of Thomas steel of mediocre quality, of which the consequence was the appearance of numerous cracks.

Engineers in this country and elsewhere cannot but agree with most of the points brought forward by Professor François and Monsieur Gerbeaux. It seems certain that the Hasselt bridge accident can be attributed to the lack of application of the rules governing the choice of a suitable steel and the rules governing the execution of satisfactory welds. This ignorance has not escaped the attention of certain welding specialists—for example, some months before the accident Monsieur Gerbeaux published a criticism on certain welding failures, which now has a direct bearing on the accident. Likewise, a Belgian engineer, Monsieur G. Morressée, published last year an article which pointed out the dangers of internal stresses in assembled welded parts, which sometimes seem to be in a state of "critical resistance." This engineer joins with Professor François in the recommendation of a suitable heat treatment for such assemblies as may be considered dangerous. The accident to the Hasselt bridge provides a lesson and shows how much justified were the calls to prudence on the part of the welding specialists. To profit from the lesson, from now on structural engineers will not neglect any of the rules which are recommended, and the rules themselves will be codified with the collaboration of welding engineers.

Literature.

The Flow of Homogeneous Fluids Through Porous Media. By M. MUSKAT, Ph.D. London: McGraw-Hill Publishing Company, Ltd. 1937. Price 45s.

IN more than one recently published book the subject of "fluid mechanics" has been discussed and expounded by writers who have sought, with considerable success, to provide elementary expression of natural laws, a knowledge of which or, at least, of their application to particular problems, is often necessary in many branches of engineering practice. On the other hand, investigators whose numbers have rapidly increased within the last few years, have studied the subject of "soil mechanics" with the aid of experiments with natural soils and materials of simpler and more easily defined character; their purpose also being to provide expression of natural laws and to establish data applicable to engineering and agricultural practice. Experiments with materials restrained under conditions intended to reproduce those of retaining wall dispositions have also come into the picture. Preceding and accompanying this recent literature there is that of water as studied, in the mechanical aspect, by engineers and physicists, in which may be found studies relating to the flow of water through soils and including those of recent investigators in India more especially.

It is obvious, however, that the ground covered, or yet to be covered, by such literature requires subdivision providing a place for the separate and elementary presentment of the subject of the flow of fluids through porous media, and equally obvious that for consideration of homogeneous fluids only in that relation a volume of considerable size is necessary. This Dr. Muskat has supplied in the work under review, which includes, in regard to oil, exposition of conditions which, as relating to water, are fairly well understood by civil engineers generally. Well qualified, both scientifically and as a writer, for this task, the author has made very good use of the literature relating to his subject, upon which he has also brought to bear the team work of his colleagues in the laboratory of the Gulf Research and Development Company (Texas), in whose service he occupies the position of chief of the Physics Division. The first chapter of his book, an excellent introduction of fifty two pages, has been contributed by Mr. R. D. Wyckoff, staff geophysicist of the company. That the cradle of the book was the laboratory of an industrial company whose directors regard it as desirable to employ a considerable staff for the study of physics in relation to their activities is a fact of some significance as regards the importance of the subject. This relation nowise affects the character of the volume as a general and elementary treatise, in which it has been necessary, with respect to oil and gas, to provide information not widely shared amongst civil engineers and to explain what few of them understand, without pursuing the subject, beyond the scope of the book, to include consideration of the nature of the flow of gas-oil mixtures through porous media, which is, the author explains, the fundamental physical problem in most actual cases of oil production.

With his purpose clearly defined, the author has presented and expounded his subject with conspicuous ability. The processes of thought by which he arrived at decisions in regard to the character and order of his exposition are reflected in his preface. His reason for deciding to make it "as complete as possible" was: that there are available neither comprehensive elementary treatments providing an introduction to the more advanced developments of the subject; nor, on the other hand, collected advanced discussions of any completeness requiring a more elementary introductory exposition as a background. He further explains that the expression "as complete as possible" does not imply that an attempt has been made to discuss every problem of fluid flow, his purpose being, rather, to treat all typical problems that are of some practical interest. These problems include some of the greatest importance in engineering practice and the author's expositions of the application to them of theory as developed in preceding chapters will serve to harmonise theoretical and illuminate practical aspects of design. As regards the methods of solution, the author makes no claim to originality, explaining that they are all well known developments of potential theory and the theory of heat conduction; but that a large part of the actual analysis has been taken from his own published papers and those of his colleagues, or from derivations prepared for the purposes of the book. The volume is a large one, for if the space occupied by the 763 pages and the numerous mathematical expressions be regarded as equivalent to words occupying the same space, the book is, in that sense, to be regarded as one of nearly 300,000 words. Scrutiny of the work makes it evident, however, that the author has been well inspired as regards the extent to which verbal explanation and discussion can usefully be employed in a work of this character. He provides, with respect to individual cases or problems, full verbal explanations of what would, by some authors, be left to be conveyed by graphs or mathematical expressions, briefly introduced. This is a valuable feature, often enabling a reader to see as a whole a solution which would otherwise be accepted only as the last of a series of steps in reasoning; a case of conviction as distinct from understanding. Similarly, each of the chapters begins with a well-composed introduction, in which the subject to which it relates is defined and discussed, and, with two exceptions, ends with a "summary" of considerable length, not a mere recital but an exposition in itself. With respect to it as a whole, Mr. Wyckoff's introduction to Part I, Foundations, provides an explanation of the topographical and ground conditions to which the study relates, and discussion of the scope of its applications, especially with regard to conditions under which oil or gas is produced. He also discusses the properties of porous media; general qualifications governing the analytical theory; the packing of spheres and of natural media; the different kinds of rock and their fluid-bearing qualities; the structure of rocks in relation to underground fluids; the occurrence and migratory behaviour of sub-surface fluids, and the occurrence of gas and oil. The whole of Part I is essentially non-mathematical. Part II, the longest, relates to problems of fluid flow in the steady state; Part III to the flow of liquids in the non-steady state; and Part IV gives the solutions for typical cases of gas flow.

The author's exposition in Part I begins with consideration of Darcy's Law, to which sixty-six pages are devoted, including some nine pages of tables giving the permeability and porosity of oil sands found in different parts of the United States, and other data. Proceeding to discuss general hydrodynamical equations for the flow of fluids through porous media, he presents a generalised form of Darcy's Law and discusses the equation of motion. Observing that the fluid systems to be studied will frequently possess special types of symmetry and that it will therefore be convenient to express the basic Laplace's equation in co-ordinate systems in which the symmetry of the system can appropriately be expressed, he re-writes the equation in cylindrical and spherical co-ordinates and, on the assumption that φ represents a velocity potential, gives the velocity components in the new co-ordinate systems. The six chapters in Part II relate, respectively, to: two-dimensional flow problems and potential-theory methods; three-dimensional problems; gravity flow systems; systems of non-uniform permeability; two-fluid systems; and multiple-well systems. Applications to typical cases include the uplift pressure on a dam of extended base width, with and without sheet piling. The study of the case with sheet piling includes a criticism of the investigations of E. M. Taylor and H. L. Uppal (Punjab Irrigation Research Institute, Res. Publication, 2, Nos. 3 and 4, 1934). Asserting that, while the line-of-creep theory is only approximate from a quantitative point of view, its fundamental assumption of a streamline following the base of the dam and the sides of the piling is strictly correct, he observes: "Unfortunately, the existence of this streamline is the subject of insistent denial in the discussion by Taylor and Uppal of their otherwise beautiful experimental work on the streamlines of models of dams with and without sheet piling." His further observations may confirm a suspicion, felt by some engineers, that many model experiments of this nature are adversely affected by the smallness of the scale of the model. Mr. Muskat reproduces three of the photographs furnished by Taylor and Uppal, one of which he compares with a diagram of theoretical potential and streamline distributions, observing that the comparison shows that, in so far as the experimental models are refined enough to give details of the motion, "they do agree with the theory given here." There follow studies of seepage of "flux" under dams and under cofferdams. The study of three-dimensional problems involves an exposition of spherical flow computation, and the applications relate to partially penetrating wells. The chapter on gravity flow systems includes an exposition of considerable length of the case of seepage through a dam with vertical faces, the analytical theory being fully developed. Seepage through a dam with sloping faces is also discussed, and consideration given to seepage from ditches and canals. The study of systems of non-uniform permeability includes discussion of the theory of the acid treatment of limestone wells and the effect of that treatment in highly fractured limestones.

The subject of this work is one of great importance in civil, municipal, and agricultural engineering and is of considerable significance with respect to some industrial processes. With special regard to oilfields, but without thereby prejudicing the scope and character of his work in other respects, Dr. Muskat has, in a book of conspicuous merit in the literary aspect, very ably presented the groundwork and expounded the theory of his subject, while providing also a basis for and exemplification of the application of theory to engineering problems.

La Locomotive à Vapeur. By ANDRE CHAPELON. Paris: J. B. Baillière et Fils. 1938. Price not stated.

Is it not strange that in the native land of the steam locomotive the technical books about it can be numbered on one hand, and that not for many years has one of the first importance appeared? In fact, we have to go back more than three-quarters of a century to find an English book of prime quality. Zerah Colburn and D. K. Clark's "Recent Practice in the Locomotive Engine" (1860) is a magnificent work of large size with splendid plates, and the only book in its class in the English language. Before that time there were several works of importance, of which Nicholas Wood's "Treatise on Railroads" was the most notable, and since 1860 several authors have dealt with the subject. Amongst them may be mentioned Bowen Cooke, Vaughan Pendred, and last, but not least Ahrons. Cooke's book is a general review of value historically; Pendred's is a "general" work written, at least in some measure, like Pettigrew's "Manual of Locomotive Engineering" for students; and Ahron's alone, in his "Development of Locomotive Design," deals fully with technological questions. The remaining works are for the most part descriptive catalogues of the engines of particular lines, or general books, not very technical, on locomotive development. In America a number of volumes on particular types have appeared, and in Germany a few scientific works on special features of the steam locomotive have been published.

But not one of these works, British, American, or German, can compare in completeness with that of Monsieur Maurice Demoulin, or that of Monsieur Edouard Sauvage which has run through several editions since its first appearance in 1894, or of yet another book of the first importance from a French pen which now lies before us. This is a quarto volume, some 2½in. thick, with innumerable illustrations of all kinds, and, as far as we have been able to discover in a reasonable time, every aspect of the steam locomotive is considered in it. When we add to these indications of thoroughness that the author is Ingénieur Chef des Etudes du Matériel to the P.O. Midi railways, we have said enough to show that the work is one which may take a proud place beside the classics to which reference has already been made. It is perhaps worth adding that on British railways we have no one who exactly fills the position occupied by Monsieur André Chapelon, though that held by Sir Harold Hartley on the L.M.S. is nominally somewhat the same.

It would be quite impossible to pass the whole of such a large and detailed work in review, and we shall perforce have to content ourselves with an indication of the method of treatment followed by the author and the general scope of his labours.

A foreword by Monsieur Edouard Sauvage and an historical introduction are followed by a chapter or section on Recent Developments, in which much attention is paid to modern arrangements for reducing back pressure by facilitating the exhaust, and to the employment of superheating. Here we find a very striking diagram which illustrates the rapidity with which advance has taken place in locomotives during the past ten years. Between 1910 and 1920 a position

of stability was reached, the maximum horse-power was about 2000, the total weight 93 tons, and the working pressure 16 atmospheres. In the next nine years the horse-power rose to 2700, the weight to 112 tons, and the pressure to 17 atmospheres. In 1931 the maximum power had reached 3200, the total weight 126 tons, and the pressure 20 atmospheres. These figures are actually for Orléan engines, but they may be regarded as nearly typical.

Many pages are then devoted to a survey of locomotive types. This section is well illustrated, but the drawings, of which there are many, suffer by excessive reduction. It concludes with a chapter on Performance, and here, again, we find an illuminating diagram, this time devoted solely to speed. It was drawn apparently before the 112 m.p.h. and 114 m.p.h. records of the L.N.E.R. and L.M.S. were attained with normal trains. The laurels are given to the Pennsylvania "Atlantic," which as long ago as 1905 covered 3 miles at 205 kilom. per hour with a four-vehicle train. Whilst it cannot be denied that special high-speed achievements do give an indication of the potentiality of locomotives, we suggest that a better impression of the position may be derived from the time-table speeds which are attained daily in normal service.

We come now to a section, occupying nearly one-half the total volume, devoted to the heat and thermodynamic problems of the steam locomotive. The treatment is far more practical than theoretical. For example, there may be found here a discussion of the effects of scale in boilers, notes on the proportions of superheaters, an essay on furnaces and firing, and all the other matters concerned with the conversion of heat into work in the locomotive. In the opening pages of this section eight "laws" with many sub-laws are presented. One or two may be quoted to show their nature: "For a constant cross-section of exhaust pipe the back pressure varies as the square of the weight of steam consumed." "With forced firing the back pressure increases more rapidly than the vacuum in the smoke-box." "The draught produced by the exhaust through a pipe of fixed cross section effects automatically an equilibrium between the production and expenditure of steam"; and "The coefficient of the decrease of tractive effort with increase of speed is proportional to the theoretical maximum tractive effort of the engine." Each of these "laws" is developed and discussed with the help of simple algebra, and in some cases illuminating curves are given.

There follows logically a section on the dynamics of the locomotive. Here we find included such matters as the "fatigue" of underframes and of straight and crank axles, and the wear of tyres. In the last connection Monsieur Chapelon points out that the tyres of the actual driving wheels wear more rapidly than the tyres of the coupled wheels, and he says that good design requires that the number of driving wheels should be high, and that the tyres should be harder than on the coupled wheels.

The next section discusses the Power and Useful Effect (*effet utile*) of the Locomotive, under such subheadings as Adhesion, Resistance, Draw-bar Pull, Limits Imposed by the Output of the Boiler, &c. Then comes a chapter on the Testing of Locomotives. An interesting point made here in connection with testing platforms is that with the help of the high-speed cinematograph it is possible to examine in detail the deformation of parts that occur in the frames and the engine itself under a variety of running conditions. This is an aspect of the locomotive testing plant which has so far received little attention in this country, but it is one which may prove to be of considerable importance. The two concluding chapters deal with the driving of locomotives and their general design.

In his final words Monsieur Chapelon insists that great possibilities for the further development of the steam locomotive exist. He foresees commercial speeds of 85 or more miles per hour—if the permanent way and its adjuncts are made suitable—and he holds that if such speeds are regularly attained, railways, owing to their superior comfort, safety, and efficiency, will be able to meet the competition of the automobile and the aeroplane.

A number of large-scale drawings bring the volume to an end.

After careful perusal of this large volume we can say honestly that we have found in it hardly a page on which something of interest to the locomotive engineer does not appear. It is written by a man who knows the steam locomotive by heart, and has such intimate knowledge of its design and operation that he is able to go direct to the essentials of all questions and in many cases is able to express his conclusions in statements which have the comprehensiveness and conciseness of "laws." Romance writers of old when they wished to praise an infidel for his valour used to say of him that had he only been a Christian, he would have been the finest man in the world. We are tempted to say of this work that our only regret with regard to it is that it was not written by an English engineer.

Wood Preservation. By G. M. HUNT and G. A. GARRATT. London: McGraw-Hill Publishing Company, Ltd. Price 30s. net.

THERE has long been need for an up-to-date book which would serve both for students in schools of forestry and engineering and as a reference work for those connected with the wood preserving industry. There is extensive literature on the subject, particularly in the publications of the U.S. Forest Products Laboratory, the American Wood-Preservers' Association, and the American Railway Engineering Association; but no book written in English during the past twenty years has seriously attempted to summarise the essential facts contained in this mass of information and to provide an easily accessible and orderly presentation of the fundamental principles involved. The authors' object was to produce such a book, and it must be said that their object has been fully accomplished, the result being a complete and concise account of the subject written in an easily readable form.

There are twelve chapters, dealing with The Field of Wood Preservation, Agencies of Wood Deterioration, Wood Preservatives, Preparation of Material for Treatment, Wood Preserving Processes, Factors Affecting Penetration and Absorption, Economic Aspects of Preservative Treatment, Properties of Treated Wood, Treating Plant and Equipment and Fire-retarding Treatments, and each chapter is concluded by a useful list of references. Concerning wood preservatives, the authors quote from a treatise published in 1817: "Almost every chemical principle or compound of any plausibility has been suggested in the course of the last five years," and state that since then an untold number of substances have been proposed as wood preservatives. They issue a warning against preservatives of unknown composition, for which exaggerated claims are made, stressing that the use of misrepresented preservatives is especially favoured when both promoter and prospective purchaser are not well informed on the subject. Of particular interest is the chapter dealing with the economic aspect of preservative treatment, accurate data being presented based on authentic records of service tests. Another very useful chapter is the one dealing with fire-retardent treatments. Both authors being authorities on this subject has enabled them to present a more complete and detailed account than is usually found in such books. The form in which the book is presented and the numerous illustrations make it an excellent textbook for students, as well as a valuable work of reference to all interested in the subject of wood preservation.

SHORT NOTICES.

The Works Engineer. By W. R. J. Griffiths, M. Inst. Fuels, in collaboration with W. O. Skeat, B.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 21s. net.—This book is intended as a practical guide to works engineers and managers and covers the various types of plant and equipment likely to come under their charge. The opening chapter covers office organisation and routine necessary for the efficient management of a large plant, and it deals with such matters as plant records, estimating, depreciation, costs, &c. Following chapters deal with the upkeep, repair, and maintenance of steam plant; water, gas, compressed air, and vacuum installations; electrical equipment; millwrighting, repairs, &c. fans, ventilation, and air conditioning; heating; building construction and lay-out; and timber work. A chapter on Safety covers the reporting of accidents, guarding of plant, industrial diseases, &c., and another chapter describes the equipment and organisation of a fire brigade. In order to keep the book within reasonable limits much of the information is of necessity quite brief, but there is no doubt that it contains much of interest and value to works engineers.

Foundry Sands. By T. R. Walker, M.A. London: Charles Griffin and Co., Ltd., 42, Drury-lane, W.C.2. Price 4s. net.—This little book is the tenth of the publishers' technical series, and, like the companion volumes, covers its subject in a strictly practical manner. It deals with foundry sands, particularly as applied to steel foundry work. Opening with a short description of the origin of sands and clays, the author proceeds to describe the important properties of foundry sands and the characteristics of sand grains and clays. The testing of sands and the methods of carrying out such tests are dealt with at some length. Two chapters are devoted to the various materials used and the practical advantages and disadvantages of dry and green sand moulding. A description of a number of the materials used in core making includes information on the properties of the various binding materials. The subject is presented in a clear and concise way, and the author, in his capacity as chief chemist and technologist to the English Steel Corporation, Ltd., is particularly qualified to write upon it.

BOOKS RECEIVED.

Elements of Thermodynamics. Second edition. By E. M. Fernald. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 21s. net.

Mechanics of Machinery. Second edition. By C. W. Ham and E. J. Crane. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 24s. net.

Empire Trade: A Concise Handbook to the Markets of the British Empire. By W. H. Wilson, B.Sc. London: P. S. King and Son, Ltd., 14, Great Smith-street, S.W.1. Price 10s. 6d. net.

Warrington Smyth Memorial Lecture, 1938: Metal Mining Enterprise. By Professor S. J. Truscott, D.Sc. London: Macmillan and Co., Ltd., St. Martin's-street, W.C.2. Price 1s. net.

Reinforced Concrete Piling. By F. E. Wentworth Shields, O.B.E., M. Inst. C.E., and W. S. Gray, B.A., M.A.I. London: Concrete Publications, Ltd., 14, Dartmouth-street, S.W.1. Price 8s. 6d. net.

Obituary.

ALGERNON CHARLES PEMBERTON.

THE late Algernon Charles Pemberton, who died on May 31st, was long connected with the Emery Mills of W. J. Davies and Sons, of Weston-street, S.E., and for some years in association with Messrs. John Oakey and Sons. He was a self-taught engineer of remarkable gifts. These gifts, unfortunately, were not perceived in his youth, and after being privately educated in Gloucestershire, he entered his father's office in Mincing-lane and devoted himself for some years to the rice trade, for which, it might be said, he had little aptitude.

As a boy his interests and ideas had all been mechanical. He built himself a lathe when he was but twelve years old, and his ability as a turner in metal was remarkable from his early years. When he did obtain his freedom from mere commerce, he set up a wood-turning factory at Rickmansworth, employing a machine for cutting spirals of a kind not before then seen in this country, though it was in some part an adaptation of an American machine already in existence. That was an invention of great ingenuity, and is still in use in the Midlands; but the factory itself, built entirely under his supervision and direction, failed for lack of capital, and some years passed which found him engaged in quite humble engineering activities. A second chance came when he was called in to save, if possible, the fortunes of the firm of W. J. Davies and Sons, then in liquidation. An exceedingly clever "blower" was his first effort for the company, and proved a signal success, finer emery than any yet produced being obtained by it. He established the company and conducted it to great prosperity, enhanced when it was taken over by John Oakey and Sons, Ltd.

Algernon Pemberton was responsible for many inventions—some minor, some which should have been of major importance. He was fertile in ideas and an excellent craftsman. As a young man he was in the championship class as a racing bicyclist on the ordinary and as a dry fly fisherman he had few equals. Equally, he was a first-rate shot, especially with the revolver, and it used to be said with some humour that there was an occasion when he provided the leading constables of Rickmansworth with revolvers entirely taken from his own extensive collection.

Altogether, he was a man of strong personality and character, and his popularity with his men was unfailing.

WILLIAM ARTHUR BONE.

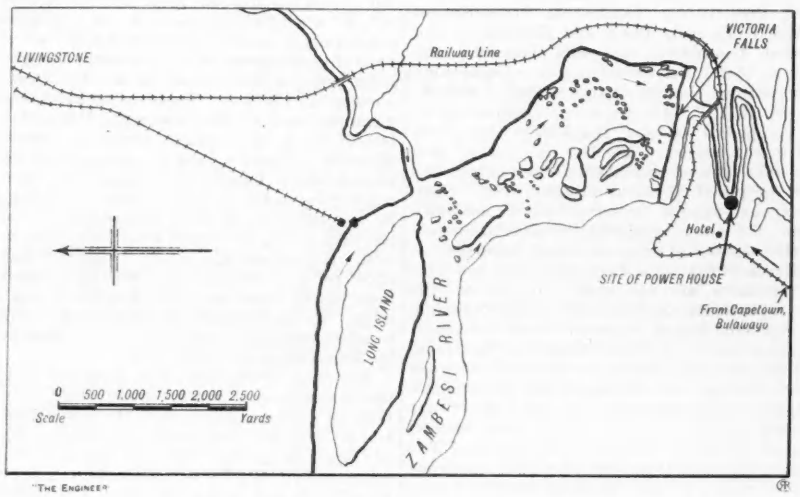
FUEL and combustion engineers throughout the world will learn with deep regret of the death on Saturday, June 11th, following an operation, of Professor William Arthur Bone, who for many years was the chief Professor and the Head of the Department of Chemical Technology at the Imperial College of Science and Technology at South Kensington. Professor Bone, who was in his sixty-eighth year, was born in Stockton-on-Tees, and received his education at the Friend's School, Ackworth, the Middlesbrough High School, the Stockton Grammar School, and the Ley's School, Cambridge. In 1891 he graduated in Chemistry at the Victoria University, and gained the Mercer Scholarship, and the Le Blanc Medal in Metallurgy. After becoming the Barclay Fellow of Owens College and Fellow of Victoria University, he decided to continue his studies in Germany under Victor Meyer at Heidelberg. On his return to England in 1896 he was appointed to the Battersea Polytechnic as Head of the Chemical Department, and two years later he returned to Manchester as Lecturer in Chemistry and Metallurgy in the University. This appointment he held until 1906, when he was appointed to the Livesey Chair of Fuel and Coal Gas Industries in the University of Leeds. In 1912 he became Chief Professor of Chemical Technology at the Imperial College, South Kensington, a position which he held with distinction until 1936. His work for the Government and scientific institutions covered a wide field. He was appointed Consultant to the Fuel Research Board in 1917, when that Board was formed, but resigned the following year, owing to expansion of the work at South Kensington. He was a member of the British Association's Coal Conservation Committee of 1918, and Chairman of the Blast-furnace Reactions Research Sub-Committee of the British Iron and Steel Federation in 1933.

Among his inventions may be recalled the Bone-court system of incandescent surface combustion, for which he was awarded in 1913 the Howard Potts Gold Medal of the Franklin Institute, Philadelphia. Other awards included the Medal of the Royal Society of Arts in 1922 for work on brown coals and lignites, and the Melchett Medal of the Institute of Fuel in 1931 for his outstanding work on the preparation and use of fuel, and the Davy Medal of the Royal Society in 1936 in recognition of his research work on the mechanism of the combustion of hydro-carbons and the nature of gaseous and flame explosions. As an author, he was well known by several standard treatises on coal and gaseous combustion, and he frequently read papers before scientific institutions.

Water Power from Victoria Falls.

THE first plant for utilising the energy available at the Victoria Falls has now been installed. The new power station was opened on March 17th by the Governor of Northern Rhodesia, Sir Hubert Young, who started up the generator, while Lady Young switched on the current to Livingstone, until recently the capital of the Colony.

More than thirty years ago the idea of supplying the Rand with power from the Victoria Falls was considered. The overhead lines were to cover a distance of about 700 miles, at a pressure of 150,000 volts. So spectacular a project appealed to the general imagination, but technical people regarded it as hopeless of realisation, although the Victoria Falls and Transvaal Power Company came to an agreement for the use of water from the falls, if required. With the developments which have taken place in the intervening years, the engineering of this long-distance transmission would be much easier to-day than it would have been in 1906. However, there is, as yet, no intention of undertaking a scheme of that kind. The present small hydro-electric installation consists of two 1000-kW sets, which are to supply the requirements of Livingstone and the large hotel at the falls. The plant will be able to supply, in addition, any industries of a normal size which may possibly be attracted to the town. With Northern Rhodesia a great wealth-producing country, spending large sums on wages and materials of all sorts, and producing well over £10,000,000 a year from the copper mines alone, it is quite possible that new and increasing activities may come into being at Livingstone.

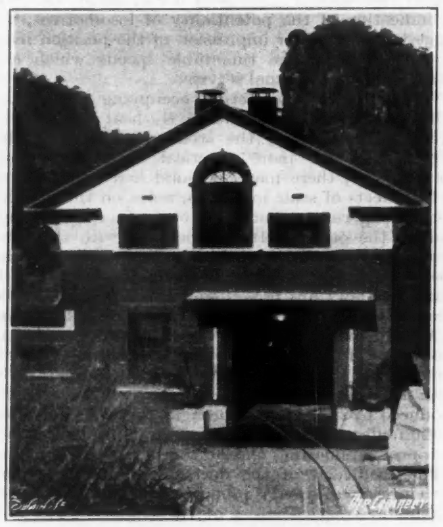


MAP SHOWING SITUATION OF VICTORIA FALLS POWER STATION

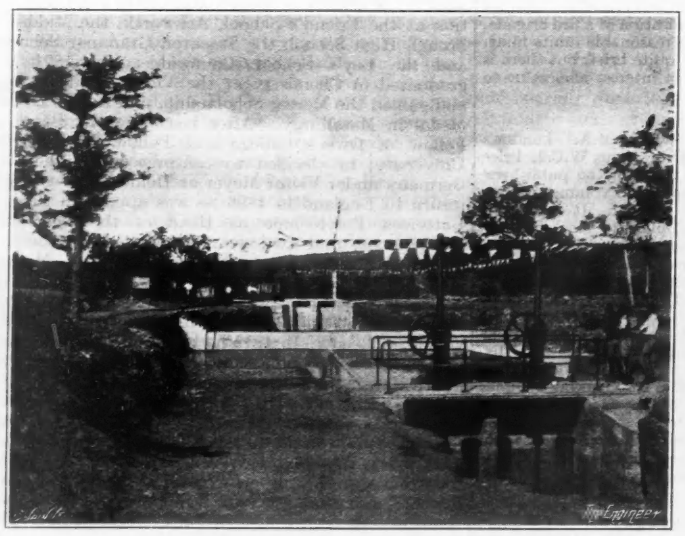
The hydro-electric power station is remote from any large industrial centre, so that the conditions under which the plant has been erected were more than usually difficult. The contract for the whole of the machinery, switchgear, and transformers has been carried out by the English Electric Company, Ltd. Messrs. Reunert and Lenz, South Africa, obtained a portion of the contract in respect of radial gates, while Guest, Sykes, Ltd., carried out the erection of the sluices and valves. Pipes for the penstock were supplied by Reunert and Lenz, Ltd. While for the present only two sets of 1000-kW each are being installed, provision has been made for an ultimate capacity of 4000 kW. The erection of the power-house presented unusual features. The site is close to the water's edge beside the famous "Silent Pool," Stringent conditions were laid down to obviate any disfigurement of the site, and the resultant problem was ingeniously surmounted. For passers-by, the building, as well as the penstock, is hidden by the surrounding vegetation. The plans of Mr. George A. Stewart, M. Inst. C.E., of Johannesburg, consulting engineer to the Victoria Falls and Transvaal Power Company, provided for an unobtrusive brick building measuring 77ft. by 57ft. overall, the levelling of the foundations requiring much care. To allow access to the station a permanent haulage track is installed. The expenditure is stated to have been about £150,000 for the whole of the works, generators, &c. The two 1000-kW alternators are driven at 1000 r.p.m. by horizontal shaft reaction water turbines working under a net head of 347ft. The electrical supply is three-phase, 50 cycles per second, at 3300 volts, and the generators are designed for 0·8 power factor. In accordance with the maker's usual standard, the turbine runners are overhung on the alternator shafts, and the spiral casings are mounted on extensions of the alternator bed-plates, an arrangement which greatly simplifies correct lining up and leads to a rigid and well-balanced generating unit.

The power station building is erected on the side of the "Silent Pool," and it was felt that the hot conditions made it advisable to avoid the necessity for the continual attendance of operating engineers. Consequently the plant was designed to run as an automatic station, a daily visit of inspection being the only attention to be given to it in normal circumstances. At present the expected load is well within the capacity of one machine, the starting of which is effected by the hand operation of sequence switches. On the pressing of a starting button in the power station the machine runs up and commences to deliver power, no further manual control being necessary. The main steps in the starting sequence are as follows :—(1) The opening of the main valve, which is of the cylindrical balanced type and needs no by-pass for the priming of the spiral casing : (2) the starting of an auxiliary turbine-driven oil pump for supplying pressure oil to the governor and bearings ; (3) the gradual opening of the turbine gates under governor control ; (4) the running up to speed of the turbine ; (5) the shutting down of the auxiliary oil pump on the appearance of oil pressure from a gear-driven pump attached to the set ; (6) the adjustment of alternator voltage by an automatic voltage regulator ; (7) the closing of the oil switch connecting the alternator to the bus-bars.

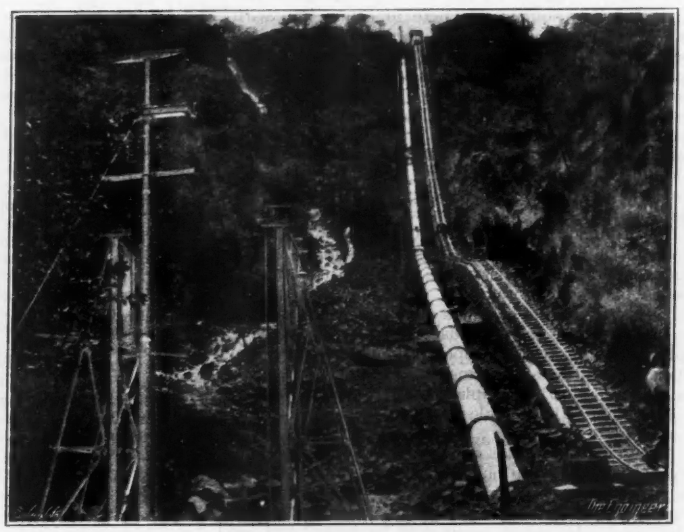
Protection during running is afforded against sustained overload, over-voltage, over-speed, failure of field current, overheated bearings, loss of oil pressure, internal machine faults, and a number of other contingencies. In case of loss of oil pressure the auxiliary turbine-driven oil pump automatically becomes available and keeps the set running, but in the event of a complete shut-down arising from any other fault the stand-by set automatically runs up, as described above. The supply is thus cut off for the few minutes required by the second machine to be brought up to running speed and switched on to the bus-bars ; but on the small system at present to be connected this is not of serious consequence. When the load grows beyond the capacity of one set a further 2000-kW set is contemplated, and eventually the station will be completed with a fourth set, also of 2000 kW. Provision has been made for the extension of the automatic control gear to the running in parallel of two or more machines, with the necessary automatic synchronising, and the design has been carried out with a view to the installation of a flexible system of automatic control whereby an increase in load will bring in a stand-by set or a stand-by machine will take the place of one that is shut down by a fault.



POWER STATION BUILDING



SETTLEMENT DAM

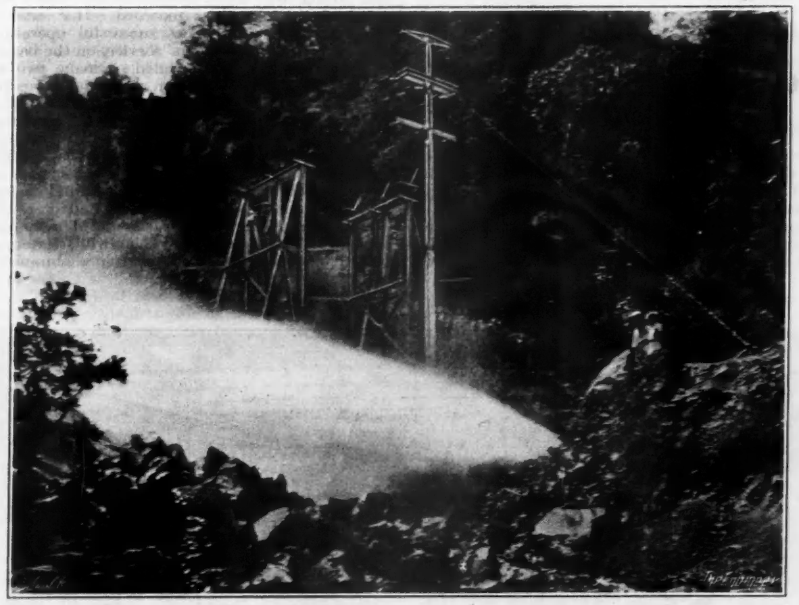


PIPE LINE

Apart from the special features required for automatic running, both turbine and alternator are of the English Electric Company's standard design. The runner is of stainless steel, the logarithmic spiral casing and the inlet bend are of cast iron, and the swivel gates integral with their stems are of cast steel. The body of the main valve referred to above is also of cast steel. The gearing mounted on the alternator

shaft has two driven shafts, one of which is connected to the governor pendulum and the other to the main oil pump. The upper driven shaft is arranged to shut down both sides of the set in the event of 25 per cent. overspeed. The draught tube is of welded steel, and fabrication by welding is also used for the bed-plate and the alternator stator frame. The rotor body and shaft of the alternator is a one-piece steel forging, the laminated poles with heavy cast steel end plates being pressed into dovetail slots machined in the periphery of the body. The journal bearings and Michel thrust bearing are flood lubricated by oil taken from the governor oil system, as is also the governor driving gearing.

The power station equipment includes two 800-kVA step-up transformers, a 3300-volt main truck type



OUTLET AT BOTTOM OF PIPE LINE, DISCHARGING UNDER 350-FOOT HEAD

switchboard, the automatic control board, a battery and battery board, and transformers and switchgear for a 220-volt station supply. Transmission to the Falls Hotel is by cable at 3300 volts, and the contract includes switchgear and transformers for giving a four-wire supply at 400 volts between phases. Transmission to the town of Livingstone is at 22,000 volts, and the voltage is there stepped down to 2200. The transformers at Livingstone and at the Falls Hotel are fitted with automatic on-load tap-changing gear.

Although this initial development uses but a minute fraction of the power available, the special features connected with the power station plant should prove a source of added interest to many of the visitors to the falls, while at the same time the scheme does not detract from the beauty and impressiveness of the scene in the slightest degree. To ensure this result, unnecessary cutting down of the bush was prohibited, and careful arrangements were demanded for the lowering of the heavy goods down the almost vertical slope without interference with the scenic attractions. An overhead crane and gantry had to be erected as the only approach to the station was down the precipitous side of the cliff. Maximum loads of 13 tons were provided for on the plans. To allow access to the station a permanent haulage track has been installed and was used at the opening ceremony.

For the intake on the river bank, somewhat above the falls, together with the 3000ft. canal, headworks, penstock, and rail haulage sidings, the Roberts Construction Company has been responsible. The photographs reproduced herewith were taken by Mr. R. D. Hothersall, of Johannesburg, under difficult conditions.

The Institution of Gas Engineers.

THE Great Hall of the Institution of Civil Engineers was filled to capacity at the opening of the seventy-fifth annual general meeting of the Institution of Gas Engineers, when the President, Mr. Harold C. Smith, M. Inst. C.E., took the chair at 10 a.m. on Tuesday, May 31st. Supporting him on the platform were Mr. Robert Robertson, M. Inst. C.E., President-elect; Mr. George Dixon, B.Eng., and Sir Frederick West, Vice-Presidents; members of Council, and distinguished visitors, including Sir David Milne-Watson, governor of the Gas Light and Coke Company; and Mr. Henry Woodall, M. Inst. C.E., chairman of the Tottenham and District Gas Company, of which the President is chief engineer.

After the minutes of the previous annual general meeting had been confirmed and signed, welcome was given to representatives of overseas gas associations and members present from abroad. The seventy-fifth annual report of the Council for 1937–8 and accounts for the year 1937 were received and unanimously adopted. They showed that the Institution was in a very healthy condition. Membership had increased to 1730, and the amount spent on research to nearly £15,000.

The presentation of the Birmingham Medal to Sir David Milne-Watson then followed, amidst applause. This award is the highest within the gift of the Institution and is only given at lengthy intervals, the last being in 1931. The qualification is distinction in efforts for the encouragement of the uses of coal gas in all directions. The President stated that it was awarded in recognition of the invaluable assistance rendered by Sir David to the research work of the Institution. They knew that where the interests of the industry were concerned no research worker pursued his object with greater tenacity than he.

In acknowledging the award Sir David said he had received no greater surprise in his life than to hear that he was to receive the medal, and he deeply appreciated the great honour which the Institution had bestowed upon him.

The Institution Gold Medal for 1937 was awarded to Mr. C. F. Broadhead, of Melbourne, for his paper on "The Consolidation of Gas"; the H. E. Jones Medal to Mr. H. Hollings, M.Sc. (London); Mr. W. K. Hutchinson, B.A. (London); and Mr. R. H. Griffith, D.Phil. (London), for joint papers on "Removal of Sulphur Compounds from Gas"; the Institution Silver Medal to Mr. J. E. Dixon (Newcastle-on-Tyne), for his paper on "Some Fuel Problems on Gasworks"; and the Institution Bronze Medal to Mr. F. O. Hawes (London), for a paper on "The Effects of Changes in Composition upon the Combustion of Town's Gas."

Then followed the President's address, which consisted of a review of the progress of the gas industry since he first came into it in the year 1906, when Mr. Charles Wood, Gas Engineer to the Corporation of Bradford, was President. At that time the membership was 812, as compared with nearly 1800 to-day, including the recent elections. Mr. Smith touched upon electrical competition, an incentive to the gas industry to achieve higher efficiencies than hitherto. Taking therms of gas and electricity sold for the years 1927 to 1936 inclusive, the total increase in the sales of gas during 1936 did not fall far below the total increase for electricity, being 62·6 million therms in gas sold, as compared with 77 million therms in the sale of electricity.

The Special Purposes Fund, established to meet the expenses of investigation and research, was referred to in the address. In 1906 contributions received amounted to £566; to-day no less than £15,000 was contributed. The subject of education in the gas industry, the work of the various research and technical committees was reviewed, and the vital questions in connection with the supply of coal were entered into. "Surely," said the President, "it is not too much for the gas industry to ask that the legislation which has been granted to the coal industry should not stop at providing machinery for the raising of prices, but should also impose obligations under penalty to supply clean coal of prescribed and regular qualities."

Mr. Smith then dealt with coke, pointing out the great value of the domestic grate in the development of the use of coke. Other by-products came under review, and he then passed on to the question of amalgamations which are being so generally adopted in this country, at the present time. He said that his company, on the subject of illumination, had never lost faith in gas as the finest medium for lighting public lamps, and had always endeavoured on assuming control of a new area, to improve the street lighting, offering additional service to the local authority concerned. These efforts had been marked by considerable success.

After a vote of thanks had been passed to the President for his address, a paper on "Considerations upon the Processing of Coal" was given in abstract by Mr. E. V. Evans, the general manager of the South Metropolitan Gas Company. This contribution was an attempt to forecast the effect which the growing and changing business of the gas industry may be expected to have upon the processes adopted for the production of a refined fuel from coal. It was pointed out that the matters discussed were largely of a theoretical nature and should be accepted as such. The market for gas as a high priced fuel for special purposes had been developed assiduously in the past, but the possible demand for a low-priced gas as a staple fuel was immense and represented the gas industry's field of development. The production of coke simultaneously with gas was unlikely to assist in the development of this new business; it might, in fact, retard the production of cheap gas.

Mr. Evans discussed known processes for the complete gasification of coal. They depended upon the oxidation of the coke resulting from carbonisation in air or steam or both. The gas was low in calorific value and of high carbon monoxide content. The production of a gas suitable for general use required the removal of this carbon monoxide and its replacement by a hydrocarbon gas or gases. Methane was the hydrocarbon gas most likely to serve this purpose. He pointed out that if a successful commercial process could be evolved on the principles which he had outlined it would represent a desirable development in gasworks practice. In his paper consideration had been given to the treatment of coal in a manner compatible with the ideas, sensitivities, idiosyncrasies, or whatever they might be called, of chemists.

Professor Cobb, Livesey Professor of Coal Gas and Fuel Industries in the University of Leeds, who, incidentally, will retire from that post in July next, opened the discussion on Mr. Evans' paper. In the course of his remarks he said that complete gasification of coal had, of course, been an established process for generations, using air and steam in gas producers, but they gave a very weak gas, quite unsuitable for distribution, as had been realised. The substitution of oxygen for air in that respect would mean a great improvement, as he and Mr. Hodsman had indicated in 1920, but the gas so made would still be lean and too rich in carbon monoxide, for one reason that the fixed carbon of the coal would still be gasified in combination with oxygen.

Dr. E. W. Smith also spoke strongly in support of Mr. Evans' suggestion for exploration into new lines of carbonisation research. The author had shown in his paper that he took a broad view, and had shown courage in speculation and had issued a warning against too much optimism. Dr. Smith held that there could be no increasing success for the industry in the distant future unless long-distance research work was prosecuted without question from now onwards.

Dr. J. G. King (H.M. Fuel Research Station) also agreed with the author's aim for further intensive research work. The paper explained the interesting results which had been obtained during experimental work on total gasification, but it remained to be seen whether it was possible to apply those results in practice. The magnitude of the promise which the research work in question held out was shown by the statement which Mr. Evans made that "The rate at which gas can be produced per cubic foot of reaction space is from ten to twenty times that obtainable by carbonisation at high temperatures." The effect on gasworks technique envisaged by that statement was surely worth striving for.

Mr. H. Hollings (Gas Light and Coke Company), in the course of his remarks, said that he could find no evidence in the paper that gas could be made more cheaply by the method outlined than by existing processes. The process before the meeting involved the use of very large quantities of hydrogen. There was available a good deal of experience concerning the cost of making hydrogen, and the most reliable estimates placed the cost at about 3d. per therm. The speaker did not see the connection between a technical discussion of processes without reference to cost, and a discussion on tariffs.

Dr. D. T. A. Townend (who is to succeed Professor Cobb as Livesey Professor) spoke next, and said that while the gas engineer had not hitherto had any strong inducement to vary the composition and range of his products, it might be questioned whether the time had not now come when he might review the position and profitably consider the claims of standardised supplies for specific purposes. Mr. Evans had shown the possibility, by the application of high-pressure processes, of a large conversion of coal into gas, mainly methane, of generally approved calorific value, together with a tar of the low-temperature type. The advantages of such complete gasification seemed very great.

Mr. T. F. E. Rhead (Birmingham), the last speaker in this discussion, dilated upon the land of promise which Mr. Evans seemed to indicate in his paper. There might be quite a wilderness of economics to pass through or to circumvent, but it would be very short-sighted to discourage such research work as had been suggested. On the other hand, it would be foolish to encourage the belief among the unthinking that a new process of gas manufacture "had arrived" and could quickly take the place of those at present working.

On resuming business in the afternoon a paper on "Carbonisation from a Plant Designer's Viewpoint" was given by Mr. F. B. Richards, M. Inst. C.E., chairman of the Woodall-Duckham Companies, London. This contribution came from the contracting side of the membership and was of excellent construction and content, treated in a masterly manner.

The discussion upon it was opened by Mr. F. M. Birks (Gas Light and Coke Company) and continued by Sir Frederick J. West, who expressed his admiration of the exceedingly interesting summary of a difficult and complicated subject. The author had given generously of the immense amount of data which must be in the hands of the great company which he represented. It was the first paper the Institution had had in which a philosophic view was taken of the design of carbonising plant in general.

Other speakers in the discussion were Mr. E. Crowther (United Kingdom Gas Corporation), Mr. G. C. Pearson (City of Birmingham Gas Department), Mr. J. W. McLusky (Glasgow), Mr. F. G. Shaw (Buxton), Mr. T. F. E. Rhead (Birmingham), Mr. S. E. Whitehead (Southampton), Mr. R. J. Restall (Stalybridge).

The first paper read on the following morning was by Mr. F. J. Eaton, Ph.D. (Gas Light and Coke Company), on "Coke and its Scientific Uses." The discussion upon it was opened by Mr. W. L. Boon (general manager, London and Counties Coke Association). Other speakers were Captain Blackie (Fuel Research Station), Dr. W. Davidson (Radiation, Ltd.), Mr. H. J. Hodsman, Mr. A. C. Hutt (London and Counties Coke Association), Dr. F. M. H. Taylor (London), Mr. Thos. Glover (Norwich).

A paper on "Cast Iron Research and the Gas Industry," by Mr. J. G. Pearce, M.Sc., Director and Secretary, The British Cast Iron Research Association, was given on resuming the Institution meeting. Mr. T. C. Finlayson, Dr. R. C. Tucker, Professor G. Turner, and Mr. G. E. Dawson were the speakers in the discussion upon it.

In the afternoon two groups were formed, one visiting the Fuel Research Station at East Greenwich and the

other going to the docks, &c., of the Port of London Authority.

Thursday morning opened with a paper on "From Holder to Burner," by Mr. W. J. Sandeman, general manager, Croydon Gas Company. It was discussed by Mr. S. E. Whitehead (Southampton), Mr. Stephen Lacey (Gas Light and Coke Company), Mr. G. M. Gill (Severn Valley Gas Corporation), Mr. P. E. Browne (Brighton), Mr. R. G. Marsh (Birmingham), Mr. C. A. Masterman (Gas Light and Coke Company), Mr. J. H. Dyde (North Middlesex Gas Company), Mr. R. E. Tennyson d'Eyncourt (Tottenham and District Gas Company).

The concluding paper was on "Works Control," by Mr. W. Hawkyard, works engineer, Willoughby-lane Works, Tottenham and District Gas Company. Dr. E. W. Smith (London), Mr. A. L. Holton (Manchester), Mr. E. G. Stewart (Gas Light and Coke Company), and Mr. W. T. Gardner (Tottenham) were the speakers in the discussion.

In accordance with long usage, Friday was given over entirely to a long-distance excursion, Southampton being the objective. By special train the town was reached at eleven o'clock. Visits were available to either (i) Southampton Gasworks, (ii) the gas showrooms and fittings department of that company, (iii) the s.s. "Empress of Britain." Luncheon was served in the Guildhall and a number of guests prominent in the town and district were present, including the Mayor (Councillor G. E. H. Prince) and Sir H. W. Russell Bencraft, chairman of the Southampton Gas Company.

In the afternoon a cruise on the Solent in the m.v. "Medina," by some, and a tour in the New Forest by others, were both greatly enjoyed, and the special train returning to London left at 5.55 p.m. from the Central Station, arriving at Waterloo at 7.27.

The Newcastle-Bergen Motorship "Vega."

THE new passenger and cargo motorship "Vega," of B. & N. Line Royal Mail, Ltd., 25, Whitehall, London, S.W.1, belonging to the Bergenske Steamship Company, of Bergen, Norway, which entered the Newcastle-Bergen service on Tuesday, May 31st, marks a further development of the company's North Sea services by large motorships, which was begun with the "Venus," a 395ft., 54ft. beam ship of 5600 gross tons and 10,000 B.H.P. engine power, seven years ago. The "Vega," which we illustrate below, was built in Italy by the Cantieri Riuniti dell'Adriaico, of Trieste, the hull of the ship being built at the company's San Marco Shipyard, and the engines constructed at the San Andrea Engine Works. With her two-banded funnels and pole masts, and her well-balanced superstructure, the "Vega" presents a handsome appearance. Her oil engine machinery is designed for a service speed of 20½ knots, which makes possible an 18½-hour North Sea crossing to Norway. The hull has been designed in accordance with the latest requirements for safety and the following are the principal dimensions and particulars :

Hull Particulars.

Length overall	445ft.
Length between perpendiculars	415ft.
Breadth moulded	58ft.
Depth moulded	33ft.
Draughtloaded	20ft.
Cargo carrying capacity	1500 tons
Gross tonnage	7500 tons
Service speed	20½ knots

Passenger Accommodation.

First-class passengers	217
Second-class passengers	248

Propelling Machinery.

Type of engines : Twin-screw, C.R.A.-Sulzer, two-stroke, single-acting

Number of cylinders	Ten each engine
Bore of cylinders	650 mm.
Piston stroke	1200 mm.
Total service I.H.P.	15,000
Equivalent B.H.P.	About 12,400
Normal revolutions	140 r.p.m.

Auxiliary Generating Sets.

Three five-cylinder B. & W. four-stroke oil engine driven generators

Designed output each engine	450 B.H.P.
Bore of cylinders	330 mm.
Piston stroke	600 mm.
Speed of generators	300 r.p.m.

The ship has six principal decks, which include the boat deck, the promenade deck, and the A, B, C, and D decks, mainly devoted to passenger accommodation. The captain's, deck officers', and wireless operator's cabins are on the boat deck, while on the promenade deck are arranged the main public rooms. These include a fine observation room forward, which runs the full width of the ship, a large entrance hall amidships, a reading room, a writing room, and a smoking room. On A deck there are first-class cabins, with the second-class smoking room and lounge aft. The dining saloons for first-class and for second-class passengers are arranged forward and aft on B deck, and amidships there are the galleys and pantries, also accommodation for engineer officers. The C and D decks fore and aft of the engine-room casings are reserved for passenger cabins, the first-class cabins being arranged forward and the second-class aft. On C deck amidships there is accommodation for the staff with messrooms.

Three holds are used for cargo carrying and they have a total capacity of about 110,000 cubic feet, of which about 70,000 cubic feet is designed for the carriage of refrigerated goods. A portion of one of the holds can be employed for motor cars, but a special enclosed space on deck is reserved for this class of traffic.

The passenger accommodation throughout is of a high order, with decoration in a pleasing modern style.

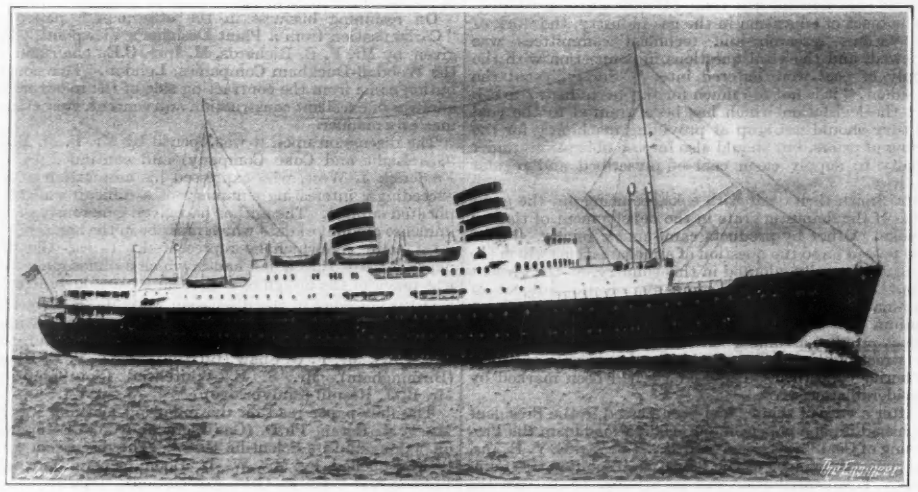


FIG. 1—PASSENGER AND CARGO MOTORSHIP "VEGA"

The Machinery Installation.

The engines, particulars of which are given in the table above, are arranged in two engine-rooms (in Fig. 2 we show the main engine-room top platform), the main engine-room having a length of 70ft. and the engine-room for the auxiliaries immediately forward of the main engine-room a length of 32ft. The pumps and air compressors were supplied by Drysdales and Weirs. All steam required for auxiliary services and heating in the ship is provided by two "Spiralflo-Steddyflo" composite waste heat oil-fired boilers, built by John Thompson (Wolverhampton), Ltd., to the designs and patents of Spanner Thimble Tube Boilers, Ltd. The boilers have a guaranteed output of 2200 lb. of steam per hour from exhaust gas at full power and of 3300 lb. per hour from oil firing with Todd burners. The working pressure is 100 lb. per square inch and the feed temperature 120 deg. Fah. The boilers are only 6ft. in diameter and 17ft. 3in. high and have a combined total heating surface of between 900 and 1000 square feet per boiler.

The "Vega" is in every way the most important ship which has yet been built for North Sea service to Norway, and during her official measured mile trials an average speed of 20¼ knots was recorded. Her sister ship, the "Venus," has given most successful operating results during her past seven years' service, on the basis of which the "Vega" is now scheduled to make two additional calls on her Newcastle-Bergen run. She leaves Newcastle-upon-Tyne each Tuesday at 7.30 p.m., and the following day, Wednesday, calls at Stavanger at 1 p.m., at Haugesund at 3.45 p.m., and reaches Bergen at 8.30 p.m. Thursday morning she leaves Bergen at 11 a.m. for Newcastle direct, arriving at 8 a.m. on Friday morning. On Saturday she leaves Newcastle for Bergen *vid* Stavanger and Haugesund at 7.30 p.m. and reaches Bergen at 8.30 p.m. on Sunday evening, returning to Newcastle at 11 a.m. on Monday morning. This schedule gives, it will be seen, but little time in port, but the good experience obtained with the "Venus" has, we learn, satisfied the owners that the new motor liner will, without doubt, easily maintain the schedule of sailings which has been arranged for her.

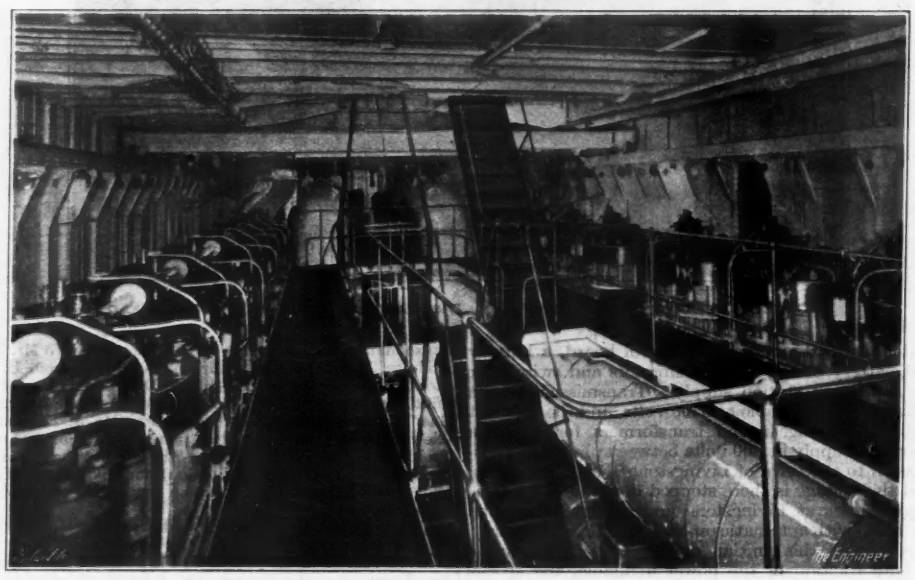


FIG. 2—MAIN ENGINE-ROOM TOP PLATFORM

The Swab River Canal.

THE North-West Frontier Province was created by Lord Curzon when Viceroy of India in 1898, after the Tirah campaign, for the purpose of imposing consistency of policy and firmness of control upon that formerly disturbed border.

The history of the Malakand hydro-electric scheme, opened by his Excellency the Viceroy of India in April last, is intimately connected with the "Upper Swab Canal," a work which has passed unnoticed in the intermittent strife in that turbulent region. Failure of crops with consequent scarcity due to ill-timed, spasmodic, and, at times, excessive rainfall were no uncommon occurrences in this part of the country, and the bold and original schemes for obtaining a secure supply of water for irrigation is due to the late Sir John Benton, Joint Chief Engineer for Irrigation in the Punjab and in the North-West Frontier Province, in the early years of the present century.

The Swab River is a branch of the Kabul River, and joins that river a little above its junction with the Indus River near Attock. The Upper Swab Canal scheme consists of a weir 700ft. long across the Swab River at Amandra, a main canal 13 miles long, and branches and distributaries aggregating 553 miles. The area commanded is 355,700 acres and the culturable area 309,900 acres. The weir lies in tribal territory, 3 miles downstream of Chakdara Fort, and contains three bays of undersluices, each 40ft. wide. The head regulator to the canal consists of nine spans of 20ft. each. The novelty of the scheme lies in the boldness of its design. For the first 4 miles of its length, which lies in tribal territory in the Swab Valley, the canal flows in a south-westerly direction, carried between high earthen embankments; the canal then crosses the Malakand range by a tunnel 11,234ft. long into British territory. Leaving the tunnel, it traverses the Dargai Nallah, a natural stream between precipitous hills for a mile. At the end of the Dargai Nallah the canal is still considerably higher than the plains it has to water; in its last two sections it has to fall over 300ft. As the slope given to this last reach involved so rapid a flow that the soil would have been considerably

eroded, the bed and sides of this reach have been lined with boulders, and the reach itself has been constructed in a series of terraces of short length with a drop of 1ft. between each terrace, down which the water passes in a series of rapids. At the end of this reach the canal drops vertically 10ft., opposite the Dargai Fort, when it bifurcates into the right and left branch canals. The main waterways skirt the base of a range of steep hills, and as they traverse extremely broken country it has been necessary to take them over and under numerous torrents, streams, and ravines by means of aqueducts, siphons, and culverts. No less than 167 of such works, including seven minor tunnels, have been constructed for the purpose. In places the canals have been carried in heavy earthen embankments with their beds at an elevation of 40ft. above the natural ground surface.

The most remarkable work in connection with the canal is the Malakand or Benton tunnel, as it is called, excavated in hard muscovite granite. Its construction took 3½ years and proved a delicate and difficult task. Special tools and instruments had to be used, and special arrangements for drilling. The latter included the training of the local men by Cornish miners, specially engaged for this purpose. The tunnel has an area of 288 square feet and discharges at full capacity 1800 cusecs.

During the early years of the work tribal opposition, due to ignorance and superstition, had to be overcome. By employing local labour as far as possible, paying royalties for quarries, granting liberal compensation for land taken up for the canal works, and enrolling a force of irregular police from among the tribes to protect working parties, stores, and plant, the opposition of the tribesmen was gradually overcome.

By April, 1914, the construction had sufficiently advanced to enable the canal to be opened. The war delayed the work for four years, when construction was completed. The capital cost of the work amounted to Rs. 2·12 crores.* In the first year of its opening the canal irrigated 7500 acres, and this area has steadily increased to 200,000 acres. The present return is 2·1 per cent. on its capital outlay, but arrears of interest on borrowed capital have to be paid off. Although not a great success from a financial point of view, by increasing cultivation and food supply the canal has done much for the welfare of the local population, while its importance as a civilising influence in bringing peace and prosperity to one of the most unsettled regions of India is out of all proportion to the cost of its construction.

MALAKAND HYDRO-ELECTRIC SCHEME.

The hydro-electric plant was originally put down at Kar some 4 miles from Malakand, in connection with the construction of the Benton tunnel, and unwatering the foundations of the Upper Swab Canal headworks. Supply was obtained from the Swab River by a channel 2½ miles long, having a bed width of 14·5ft. and a fall of 1 in 2000, discharging 125 cusecs. The fall from the forebay to the turbines was 30ft. On completion of the Upper Swab Canal works a scheme was then prepared for the electric lighting of the town of Malakand.

The plant as then installed consists of a power-house, 60ft. by 17ft., double storied. On the ground floor are installed three vertical Samson turbines, each of which is provided with a Woodward governor of the compensation type. The penstocks from the forebay are 45ft. long, 3ft. 6in. and 3ft. 2in. diameter, and ¼in. in thickness. Two turbines are rated at 120 H.P., 375 r.p.m., and the third at 80 H.P., 428 r.p.m. A draught tube projects from each turbine 10ft. down to the tail-race pit. Each turbine is directly coupled to a three-phase, 50-cycle, 2200-volt alternator of the umbrella type. For the larger sets the output is 100 kVA and the smaller one 66·6 kVA. Each alternator carries its own exciter on its shaft. The exciters are D.C. generators, shunt wound, capable of giving a full load of 50 amperes at 75 and 55 volts for the larger and smaller sets. The plant is protected against lightning by tension limiters and choke coils. Pressure is reduced from 2200 volts to 220 volts for lights by means of 7·5-kW single-phase transformers.

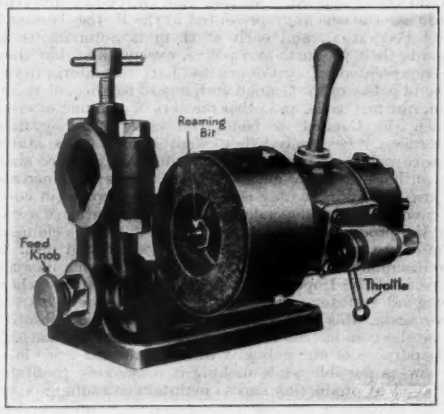
Owing to the hilly nature of the country traversed the wooden poles of the transmission lines are spaced only 100ft. apart. The line is 4½ miles in length, and is protected against lightning by horn gap arresters installed at every sixth pole, and earthed through non-induction resistances. The power conductors are of hard-drawn copper wire, No. 0 S.W.G., to the workshop sub-station and No. 3 beyond it. They are placed at three corners of a 3ft. equilateral triangle.

On the completion of the Upper Swab Canal it was pointed out by Colonel Battye, R.E. (then Captain Battye) that the fall below the Malakand, or Benton, tunnel, with the supply passing down the canal could be utilised for generating electric energy on a large scale. This new hydro-electric scheme, opened by his Excellency the Viceroy of India in April last, is estimated to cost Rs. 42 lakhs and is designed to make use of the fall of the Upper Swab Canal after its exit from the Malakand tunnel. It will supply electric energy to a wide area in the North-West Province. The drop available below the tunnel is about 230ft., giving, with the supply available, a minimum of 20,000 E.H.P.

A Drill Shank Grinder.

THE power and speed of modern rock drills has made it important to maintain a true and flat face upon drill shanks in order to obtain the maximum length of life from the pistons. The accompanying illustration shows a drill shank grinder which has recently been introduced by Holman Brothers, Ltd., of Camborne, to enable the truing up of drill steels to be carried out with speed and accuracy. A cup-shaped grinding wheel is driven by a compressed air motor which incorporates the firm's system of blade pressure control to minimise friction. Admission of air to the motor is automatically controlled by a centrifugal governor which regulates the amount of air according to the load on the grinding wheel. As the face of the cup wheel wears, the surrounding guard is moved back. The motor is mounted on a pivot on the stand in the base of the vice, and the grinding wheel is moved backwards and forwards across the work held in the vice. Incorporated in the motor pivot is the feed screw and by means of this the motor is moved towards or away from the work. The feed screw is totally enclosed, and a helical spring on the pivot prevents end play. In the end of the wheel spindle is a replaceable reaming bit for countersinking the hole in hollow drill steel, after the end has been ground.

The vice, which is incorporated in the mounting casting, is adjustable to hold steels of all the usual sizes and sections,



DRILL SHANK GRINDER

and is also large enough to accommodate pistons for redressing their front ends.

As may be seen, the grinder can be used from either side, but it is usually more convenient to use the right hand for the feed knob at the base of the vice, and the left for the oscillating handle over the motor.

Stairway Lifts for Residences.

EXTENSIVE use of passenger elevators or lifts of various kinds in the United States includes a special development in the form of small and simple lifts for use in private residences. While they are of particular value for invalids, cripples, and weak or aged persons, they are often used in the general service of the household. These lifts are of two types, inclined and vertical, and in many cases they have been applied to existing buildings with very little trouble.

The "Inclinator," shown in Fig. 1, is an inclined lift designed for installation on straight stairways, with or without intermediate landings. It consists essentially of a

FIG. 1—INCLINED STAIRWAY LIFT

small platform carried by a cable-operated trolley running on a steel channel attached to the wall, the cable being within the channel rail. As the platform, with seat attached, can be folded against the wall, then projecting less than 6in. from it, the lift does not interfere with the normal use of the stairway.

A special removable seat or chair may be fitted for the use of invalids, or a double seat for two passengers, face to face, this part of the apparatus being varied to suit the requirements or conditions in each case. A small electric hoist or winch is installed in any convenient place, out of sight, its motor being served by the house-lighting current, whether alternating current or direct current, no special power circuit being needed. Operation is controlled by push buttons mounted on the seat or car, and also at top and bottom of the stairs. Automatic limit switches check and stop the movement at the end of travel.

The "Elevette," shown in Fig. 2, is a small vertical lift adapted to be placed in a stair well, but it can be fitted also to a cupboard or in the corner of a room. Its car or platform may have solid or open-work enclosing panels, and is made of size and shape to suit requirements. A special feature is the elimination of an enclosed shaft and of all overhead construction, the car being supported—like the "Inclinator" by a trolley travelling in a single steel channel. This channel, with the cables and wiring conduits, is enclosed in a timber post harmonising with the interior finish of the room.

Operating buttons are fitted in the car, together with call buttons on each floor. Electric and mechanical interlocking provides for safety of operation. Where the car descends in an open room, a delicate safety stop under the floor of the car provides protection by stopping the car at the slightest pressure. In fact, it is said that the pet kitten can safely sleep on the carpet directly beneath the car. On the upper floor the opening is closed by an automatic trap as the car descends.

Obviously, these lifts are not built to standard designs—with the exception of the power units—but are designed according to the individual requirements of each installation, and whether for only two floors or for additional heights. They are built by the Inclinator Company

FIG. 2—LIFT FOR STAIRWAY WELL

of America, at Harrisburg, Pennsylvania, under the patents of Mr. C. C. Crispen, president of the company. In England the company is represented by the firm of J. Foot and Son, Ltd., 168, Great Portland-street, London.

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

TARMACADAM.

No. 802—1938. This new specification has been based on proposals originally prepared by the British Road Tar Association and completed after co-operation with organisations concerned with road stone and slag, local surveyors, the Institution of Municipal and County Engineers, and other bodies. Part I covers the whole range of processes involved in the preparation of tarmacadam, from binders, aggregate, and fillers to sieves, the temperature and method of mixing, transportation, and sampling and testing. Part II covers foundation work, thickness and contour, spreading and consolidating, jointing, and the application of chippings, &c.

ANNUAL MEETING AND LUNCHEON.—Nearly 300 members and guests were present at the annual luncheon of the British Standards Institution, which was held at the Dorchester Hotel on Tuesday, June 14th. The toast of "The Institution" was proposed by Mr. Ronald Cross, the Parliamentary Secretary to the Board of Trade. Mr. Cross, in the course of his remarks, stressed the value of the standards issued by the Institution as a link between the consumer and the producer, and pointed out that such standards were an important factor in promoting Imperial trade, now that they were being adopted by the Dominions. Such standards, he said, also considerably facilitated the placing of orders in this country by countries abroad. In replying to the toast, Dr. E. F. Armstrong, the retiring Chairman, gave particulars of the growth and work of the Institution and pointed out the necessity of increased financial support. He said that, comparing the income with the number of committees, each committee cost on average £30. The new Chairman of the Institution, Sir Frank Heath, coupled the toast of "The Visitors" with that of Dr. Armstrong, upon the value of whose work for the Institution he laid considerable stress. Lieut.-Colonel Lord Dudley Gordon replied to the toast.

NEW AMERICAN LOCOMOTIVES.—The American Locomotive Company has, during recent months, delivered fifty new 4–6–4 "Hudson" type locomotives to the New York Central system. Ten of these engines have been streamlined for working the Twentieth Century, Limited, express between New York and Chicago, which has recently been accelerated to do the journey of 958 miles in sixteen hours. The leading dimensions of the new engines are as follows:—Cylinders, 22½in. diameter by 29in. stroke; 14in. diameter piston valves with a maximum travel of 8½in.; boiler pressure, 275 lb. per square inch; combined heating surface, 5932 square feet; driving wheel diameter, 79in.; total engine weight, 160¾ tons; tractive force at 85 per cent. boiler pressure, 43,440 lb., and with the booster, 55,540 lb.

* £1·572 million.

Producer and Consumer.*

By SIR WILLIAM J. LARKE.

THE subject that I have chosen to talk about to you to-day I am afraid may have raised very different feelings and hopes in the minds of people, depending upon their attitude to it and as to which category they consider themselves to belong. But however that may be, one thing I would say at the outset, that I think it would be common ground that *laissez faire* as a governing principle of industrial and commercial policy in this country, and possibly in all industrial and trading countries in the world, is dead. I want to carry you back by way of introduction and in order to provide a background to the effects of *laissez faire* in this post-war period.

If I take some examples from iron and steel it is only because I happen to know the facts I am dealing with. The principles are of general application, otherwise they would have no validity. I would carry you back in memory to 1919–20, when immediately on the cessation of war there was a general rush to revert to peace activity. *Laissez faire* certainly had full play then and prices of everything rushed to fantastic levels. Such was the position up to the middle of 1920 that one of my friends told me that he sold steel plates at a certain price at the beginning of a particular month, and at the end of the same month he was going round looking for orders at a quarter of the price at which they were at the beginning. That is the effect of an unregulated policy creating conditions of uncertainty. Demand was killed, as one should have expected under such conditions. Take the other side of the picture following the same period, culminating after the collapse of values at the end of 1920–21 in the black decade lasting until 1931, when we were all in the trough of depression, particularly in this country. We found that prices went down to such a level that, to quote steel again, in 1931 prices were quoted in this market for steel from French works which realised at their works only 60 per cent. of their cost of production.

Now gentlemen, when you consider that, who benefited ? During 1921–31 it was a consumers' market, from 1919 to the middle of 1920 it was a producers' or se lers' market. But no one benefited from those conditions. Of course not. While it was a consumers' market the consumers could not consume, whatever the price quoted. Why ? Because no one can be a consumer unless he is first a producer.

The failure of our politico-economic policy, certainly from the beginning of this century onwards, really arose from the fact that for so long in the nineteenth century we considered only the interests of the consumer as though he were a special being who could exist in isolation. He cannot. Every consumer is a producer either of goods or services, or else he commands the production or services of other people and controls, through them, accumulated or inherited, means of exchange which enable him to consume. Therefore, you cannot in the long run talk about a consumers' market being favourable. It is no good thinking, if you consider the economics of it, that as producers you can increase the consumption of your products by the simple process of reducing prices. It cannot be done, unless you are in direct competition with some alternative material or product which is able to perform the same services as your own product at a lesser price. But if your own product is of a kind for which there is no real substitute, then the simple expedient of reducing prices will, I venture to say, never increase the volume of consumption provided the original price level is a reasonably economic one—that is, it is as low as is consistent with profitable and efficient production.

I think anyone who is prepared to sacrifice the future for the purpose of exploiting a fortuitous present shows a complete lack of appreciation of the underlying economics of the relations between the producer and his market. If producer and consumer are the same people it obviously follows that we as producers are but little less interested in the prosperity of our suppliers than we are in our own. It will be obvious that the only basis for consuming power is the creation of the wage fund and profits of industry generally. These are produced just as much by those who supply us as by those whom we supply in our position in the industrial chain in the community in which we are situated. These are the underlying principles on which the organisation of the steel industry is based.

Some time ago, in 1937, we found there was considerable difficulty in the coal industry, and we went to the Mining Association at their request and said to them that they must not have a stoppage in the coal industry at this time, when industry was slowly recovering. We were prepared, as an industry to pay an additional shilling per ton on all existing contracts for coal, however long they had to run, providing that the shilling was transferred to the miners and produced industrial peace in the coal industry. We said we fully recognised the owners could not provide that money, at that time. A few months later the same policy was adopted in connection with profits, and we agreed to another shilling per ton on our contracts. It was sheer common sense, not philanthropy. It was not altruistic ; we did not want a stoppage in that industry at a time of recovery, and an unprofitable coal industry was a cause of unstable commercial conditions.

During the ten years of depression the British steel industry was fighting for Protection and its own continued existence ; it did not depress prices down to the lowest level reached by foreign competition. It could not afford to do so if it was determined to survive as a capital entity. We had experienced as producers a reduction in the employment of our plant down to 30 or 40 per cent. of our capacity, and we were incurring heavy losses. But as soon as Protection was granted and imports were diverted to our own works we found we were able to maintain the same prices for staple products for three years after Protection was granted, and yet to work on a profit-earning basis. The introduction of Protection of itself did not involve an increase of prices, but it demonstrated that it was volume of production that enabled us to become efficient and to maintain low prices. That was a very valuable consideration for all of you.

Having got that far we then decided that since the Iron and Steel Federation included some fifteen industries somehow or other they all had to be brought into co-ordination. I want to emphasise the fifteen different industries. I am frequently told by friends in other industries, including this one, that it is easy to organise a single industry such as iron and steel, but that it cannot be applied to their own.

Gentlemen, it is not true. These principles cannot perhaps be applied so rapidly but they can be applied, and I hope to convince you before I finish that they can and should be so applied. No less than thirty-five different trade associations are represented in the British Iron and Steel Federation, and each of them is autonomous as regards their products and policy, except this, that they are represented on our Council and have to conform to the general policy of the Council with regard to price, distribution, raw materials, and other matters of common interest which the Council as being the final authority may determine. Generally, they shall maintain as stable a price policy as possible and no increase of price shall be authorised on a national basis unless the increase is justified by increasing costs and such increase in costs is determined by independent audit of representative works for the products of which the increased price is claimed. The industry has further voluntarily submitted itself to the discipline of obtaining the approval for such increase in price of the Import Duties Advisory Committee, there being no statutory obligation to obtain such approval. But again, this is neither altruism nor philanthropy : it is sheer industrial commonsense and statesmanship. The purpose of our policy is to maintain our price level as low as possible while making it reasonably profitable for efficient production and so maintain consuming power at its maximum possible at any time. I am confident that the policy will stand the stress of recession if there is one, and that it will have the effect of smoothing out both the peaks of boom and the valleys of depression. After all, conditions of boom and depression are neither a law of Nature nor an act of God, but are largely due to the folly of man. They are due to the fact that we as industrialists have in the past by virtue of our close contact with our work taken too narrow a view of our ultimate policy. It is quite true that in the forty odd years that I have been in industry conditions have changed. Fifty years ago the demand for the products of industry was almost unlimited, in relation to production capacity. But now in this the most highly industrialised country in the world we have to develop a relation between industrial production and the production of primary products and services which requires that if our consumption of industrial products is to be maintained our consumers must also be maintained contemporaneously in profitable operation. It is that relation in values that we have to try to establish by collaboration between our respective industries which will maintain consumption.

Early last year we stabilised prices. I have heard it said, " Oh yes, it is very clever of you to stabilise prices against a possible fall." Not at all. We did it at first against an extravagant rise. When prices were first stabilised some time in May, 1937, the steel industry was being offered by consumers prices of £3 or £4 per ton provided the consumers in question received priority of delivery. The Federation realised this must not be. If any makers accepted such prices the rise would continue by speculative competition to bring about rapidly a complete cessation of consumption and a return to depression. These offers were definitely refused and prices were stabilised at the existing level. But at the time costs were rising against the industry in the form of rising coal and coke prices. That was a very serious matter because these are a very substantial item in the cost of finished steel. We said we had stabilised our own prices and we thought they should do the same in coal and coke. I want to show how consumers and producers are one, and how we as consumers of coal and coke were vitally interested in the profitable operation of coal and coke. At the same time, it was possible for them completely to torpedo our own policy of trying to maintain reasonable prices to you as consumers.

Well, that view was more or less recognised in principle and a certain degree of stability has been introduced in the prices of our supplies.

The same thing happens in our own industry in regard to many of our immediate consumers. We represent, as I have said, some fifteen different industri . Many of these are consumers of the products of others, all being affiliated to the Federation and some of our integrated works are both producers and consumers of semi-finished products, carrying them on to a more finished stage before passing them on to their own consumers. In such cases not only are prices of the semi-finished products stabilised, but the prices of the more finished also ; thus an integrated works observes both of the stabilised prices.

We have tried to establish a proper relation between producer and consumer, and I trust that this doctrine will spread throughout the industrial structure of the country. There is no need for these very wild variations in our economic activity if the industrial community as a whole will take a broad-gauge statesmanlike view of its potential markets. People get cold feet and hot heads whenever there is a possible potential drop in demand and they want to depress prices. They forget that their consumer's power to consume is also weakening and therefore whatever you do you cannot get increased consumption ; all such a policy can do is to secure the redistribution of an ever-shrinking demand, accelerating the shrinkage until it ceases altogether by the complete destruction of confidence, the immediate result of an artificially produced falling price level.

Let me tell you the story of a shipowner who desired to place an order for a ship worth a quarter of a million. Another shipbuilder came down from the north and said, " I understand you want a ship of such and such dimension. My price is £225,000 ! " The shipowner thought he had better think things over again. Then a third man came along and offered to build it for £210,000. The shipowner said he dare not place the order at all, and that is exactly what must happen under such conditions produced in this case by the action of industry itself.

My theme then is that we should all try to organise our policy on the principle that prosperous industry must collaborate as far as possible with its consumers to maintain their consuming power. We have a duty to our workpeople as well as to our shareholders. Perhaps our greatest duty to the country as a whole is to secure the greatest volume of employment at any time. There is a greater field for industrial statesmanship than there is for political statesmanship at the present time. We know the policy I have outlined can be secured even internationally. We have tried it in the steel industry. We have established stable prices in world markets. It may be of interest to point out that during 1937 our home prices for some months were £2 to £3 a ton below world prices. It is not so to-day. World prices have fallen, and they are now more or less on a parity, though in some cases home prices are still slightly lower. We claim absolutely no credit for this. What we have done in the iron and steel industry is in the belief that it is in our own interest to serve the community as a whole to the best of our ability. We shall thus obtain the maximum amount of employment and work for ourselves and our workpeople. We hope that you as consumers will appreciate the underlying principles of the policy adopted, and will collaborate with us in maintaining industrial activity in this country at the highest possible level indefinitely, in our mutual interest and that of the country generally.

* Address at a B.E.A. luncheon on May 12th.

The Northern Ireland Electricity Board.

IN an interview with the Ulster Development Council, Mr. A. W. Ferguson, Chief Administrative Officer of the Northern Ireland Electricity Board, gave an account of the development of the Board's work since its inception in 1931. On June 1st of that year the Board was set up as a non-profit-earning body charged with the duty of promoting, co-ordinating, and improving the supply, distribution, and sale of electricity in Northern Ireland, planned on the basis of reports by Mr. J. M. Kennedy, whose advice was sought by the Northern Ireland Government at the end of 1929.

The Board's annual report for last year, Mr. Ferguson explained, gave figures which provided a broad picture of the development. Comparing the results of 1937 with those of 1932, the total number of units sold had risen from a little over 3 millions to nearly 40 millions. The average price per unit sold had been reduced from 2·26d. to 1·44d., while the revenue in round figures had risen from £30,000 to £258,000. Over the entire period the Board's capital expenditure amounted to approximately £1,600,000.

When operations began there were some seventy-four undertakings in Northern Ireland, fifteen being in County Antrim and in that part of County Londonderry over which the Antrim Electricity Company had been given development powers in 1928. The Board was first made statutory undertaker for the South-Eastern Area, comprising most of County Down and County Armagh and a small part of County Tyrone. As the result of three successive development schemes, the Board's area of supply now included the greater part of the Counties of Fermanagh, Londonderry, and Tyrone, in addition to the entire Counties of Armagh and Down.

Within that area the Board had acquired every undertaking of importance, those outstanding being too remote to justify immediate inclusion. The next step would probably be an extension through the Clogher Valley for providing an alternative source of supply to the Enniskillen district. With the exception of the Enniskillen plant, which had been kept in reserve, as the undertakings had been acquired, the generating stations had been dismantled and current drawn from the grid, which was supplied principally by Belfast. But since October, 1935, when the main transmission line was carried to Londonderry, the generating station there had also been treated as a selected station, and in 1937 close on 4 million units were purchased from Londonderry compared with 42 millions from Belfast.

In 1934 the Board decided to treat Londonderry as a point of supply to assist in meeting the demand on the network which, based on a line totalling 369 miles long, was then being extended to the far west and north of the province. As the result of the acquisition of a dozen local undertakings in that year, the number of consumers drawing supplies from the Board increased by 5000. By December, 1934, out of 18,712 consumers connected, 9000 had been previously supplied by undertakings acquired by the Board. Three years later the number of consumers connected had almost doubled, having reached a total of 36,000.

From the point of view of technical developments the year 1935 was also important. Arrangements were made in that year for the establishment of a Central control station at Rosebank, near Belfast. The number of circuits radiating from that control station had been increased, thus permitting a more complete sectionalising of the main transmission system. Interconnecting link lines are being provided which, as well as meeting the increased load, will give alternative sources of supply to important load centres.

BLOWERS AND COMPRESSORS.—We are informed by Richardsons, Westgarth-Brown, Boveri, Ltd., that the machine illustrated in Fig. 46 of our Supplement published with the issue of May 27th is one of the gas exhausters supplied by the firm to Dorman, Long and Co., Ltd., and not a blower for the Corby works of Stewarts and Lloyds, as stated in the text. The claim that they are the largest machines of their kind in Europe applies to the Dorman Long plant. The M.A.N. gas engine driven blower supplied by Spannagel, Ltd., of Westminster, to the Appleby-Frodingham Steel Company's works of the United Steel Companies group, takes gas from the blast-furnaces, and not the coke oven plant as mentioned in the Supplement, and the power of each engine is 3400 B.H.P., corresponding to an output of about 4600 I.H.P., and not 3400 I.H.P., as referred to in the article.

The Design and Operation of a Modern Blooming Mill.*

By W. F. CARTWRIGHT.†

(*Continued from page 660.*)

Scale Disposal.—There are four main scale hoppers, one under the roller gear where the chariot tips, one under the roller gear directly in front of the mill, one under the rolls, and one under the rollers just at the back of the mill. These hoppers discharge into four tubs, each on its own separate track and with a separate shaft, up which it is hoisted by the crane and tipped into the scale wagon. Scale from under the roller gear running to the shears is collected at week-ends in barrows and wheeled to a central point, where it is filled into specially designed buckets.

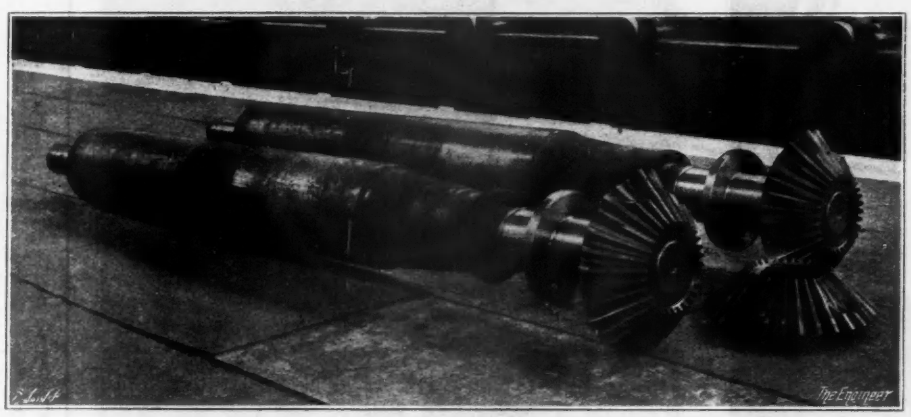
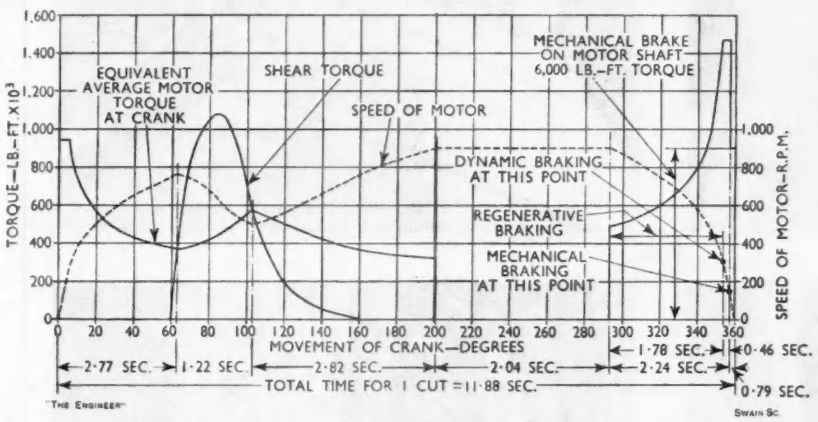


FIG. 22—*Bevel Gear with Broken Teeth.*

These are withdrawn by the crane through the roller table, a plate being removed for the purpose.

Roller Gear.—The roller gear throughout the mill is driven by twin motors, to avoid the possibility of stoppage due to the failure of the motor. The rollers run in oil-lubricated white metal bearings. The drives are by means of D.C. mill type motors, reduction gears, line shafts, and bevel gearing. The line shaft bearings of the working rollers are lubricated by means of wipers which remove oil from an oil ring and run it back into the bearing. The continuation roller line shafts wipe the oil off the back of the bevel gears. The rollers themselves have an oil ring forged solid with the shaft on the driving side, which also takes the thrust of the bevel gearing. On the other side the ring is loose. It is located laterally by the two brasses which form the bearing, and is prevented from rotating relative to the shaft by the $\frac{5}{8}$in. diameter set pin with a $\frac{1}{4}$in. head, which is screwed into the shaft, the head fitting into a recess in the ring. A number of these set pin heads broke off, and they were replaced by pins with bigger heads which are recessed into the shaft. It is not known whether heated bearings caused the brasses on either side of the rings to expand and shear the pins, or whether the pins, being weak, sheared with the result that the rings, not rotating properly, did not feed enough oil to the bearings. In any case, a number of bearings became hot; stronger dowels were put in and there has been no further trouble.

The only other trouble has been with the two rollers under the ingot when the chariot tilts it down. The roller gear is under the control of the screwer, who cannot see the chariot, and the chariot driver has great difficulty in tilting the ingot down as gently as he could wish. If the roller gear is rotating fast and the chariot driver puts the ingot down with a thump, the momentary stress on the bevel gears is very high, resulting in broken teeth, Fig. 22. No satisfactory method of overcoming this has yet been devised. At the moment all that has been done is to instruct the chariot driver to lower as gently as possible.



Shearing 12in. bloom; 16½in. crank; gear ratio, 1:120; shear efficiency, 80 per cent.; motor, 350 H.P., 50 deg. Cent. rise; peak, 650 H.P., 300–900 r.p.m.; shearing rate, one cut in 12 sec. = five cuts per min. Motor suitable for 120 cuts per hour continuously, 40 deg. Cent. rise; 156 cuts per hour continuously, 50 deg. Cent. rise; 180 cuts per hour for two hours.

FIG. 23—*Torque Diagram of Shears Motor.*

In spite of these small troubles the mill has never yet lost any time due to mechanical trouble with the roller gear.

The Bloom Shears.—A whole paper could be written on the design of this machine. It is operated by a single non-reversing motor and will shear any bloom or slab up to 12in. by 12in. in size without any adjustment.

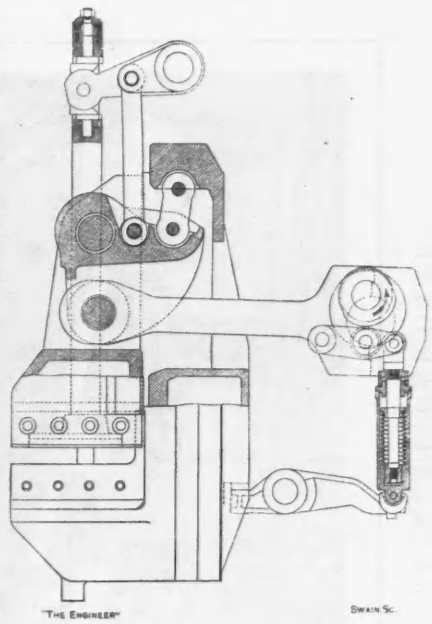


FIG. 24—*Arrangement of Shears.*

The electric drive consists of a 350 H.P. D.C. motor with a peak of 650 H.P. running at 300–900 r.p.m. On receiving the signal from the shear man the operator pushes over the control handle and thereafter the action becomes entirely automatic. When the bloom is sheared a cam on the end of the cam shaft operates contactor gear, increasing the current in the motor field circuit, and causing regenerative braking. At the end of two seconds a time relay comes into operation, breaking the main circuit and short-circuiting the motor, causing dynamic braking. Finally, the last step on the cam breaks the motor circuit and applies the magnetic brake. In the event of a number of very short blooms being required the operator closes a

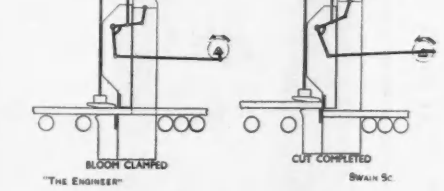


FIG. 25—*Diagram of Shear Operation.*

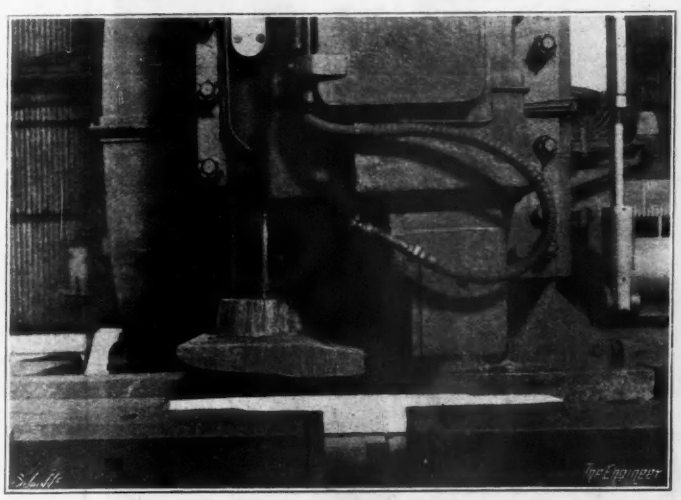


FIG. 26—*Arrival of Bloom in Shears.*

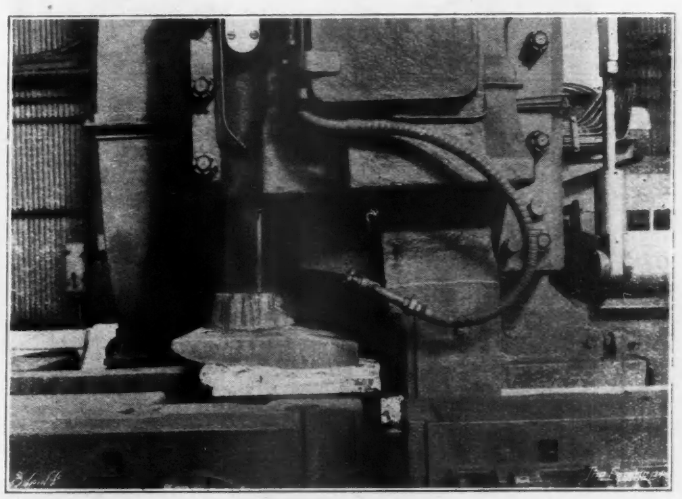
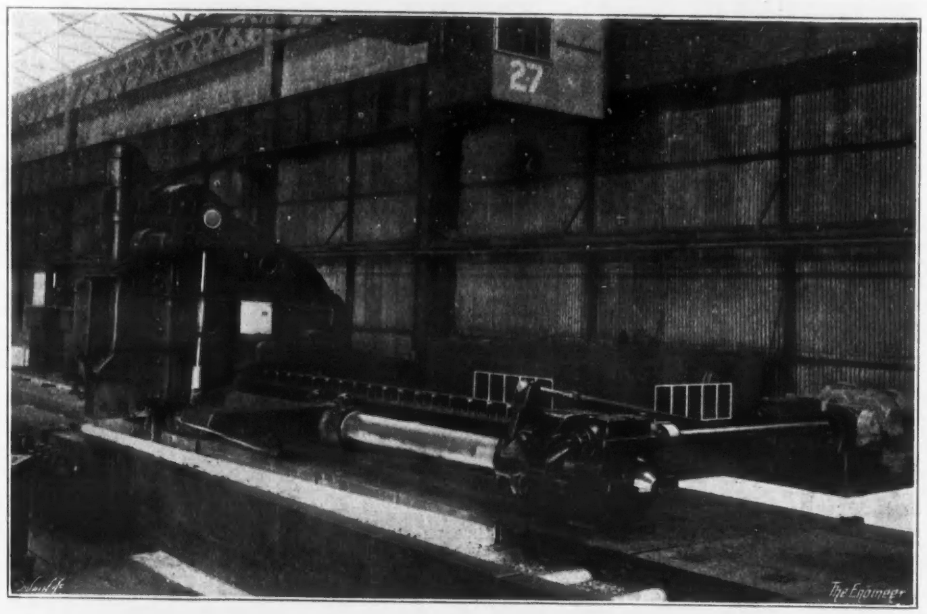


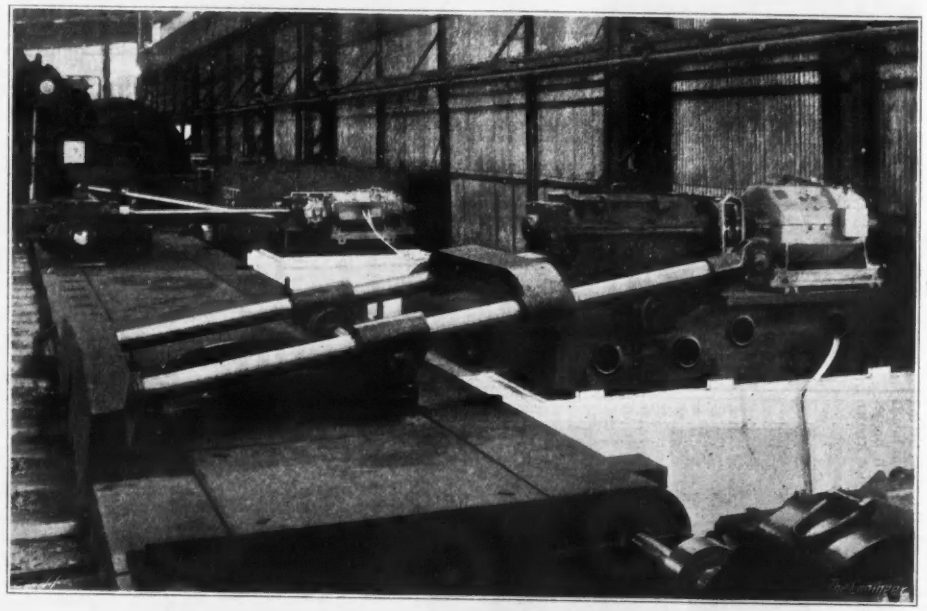
FIG. 27—*Cut Completed.*

* Institution of Mechanical Engineers—Cardiff Summer Meeting, May 31st.

† Technical assistant to the managing director, Guest, Keen, Baldwins Iron and Steel Company, Ltd.

UNITS OF GUEST, KEEN, BALDWINS 40-INCH BLOOMING MILL AT CARDIFF





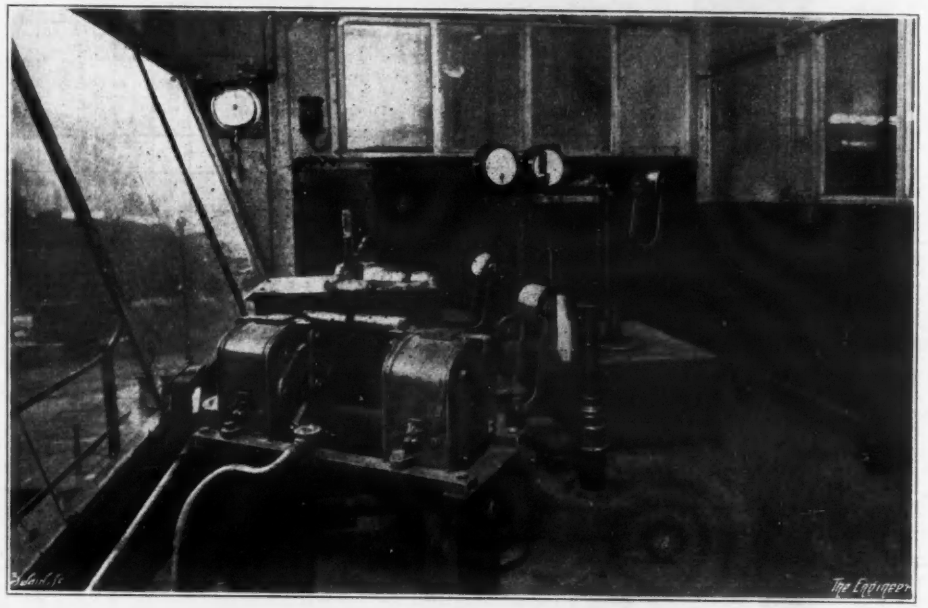


FIG. 28—*Stopper Gear.*

FIG. 29—*Push-off Gear.*

FIG. 30—*Oscillating Transfer Bank.*

FIG. 31—*View of Controls*

switch which allows the shears to operate continuously. Fig. 23 shows the torque diagram of the motor.

The mechanical operation of the shears is as follows :—On the arrival of the bloom it rests on the roller gear. The operator starts the motor. At rest the cam shaft is a little off dead centre and for the first few degrees of revolution the connecting-rod moves away from it slightly ; during that period a cam mounted on the end of the main cam shaft depresses the shock absorber shown in Fig. 24. This shock absorber, the spring being formed by a number of solid rings nesting into one another. When the whole nest is compressed vertically some of the force applied is used to overcome the friction of the rings on one another and the remainder in expanding the outer rings and contracting the inner ones. The downward movement of the clamp continues until the compression between the clamp and the bottom blade holder equals a force sufficient to raise the bottom blade holder off the base-plate and arrest the

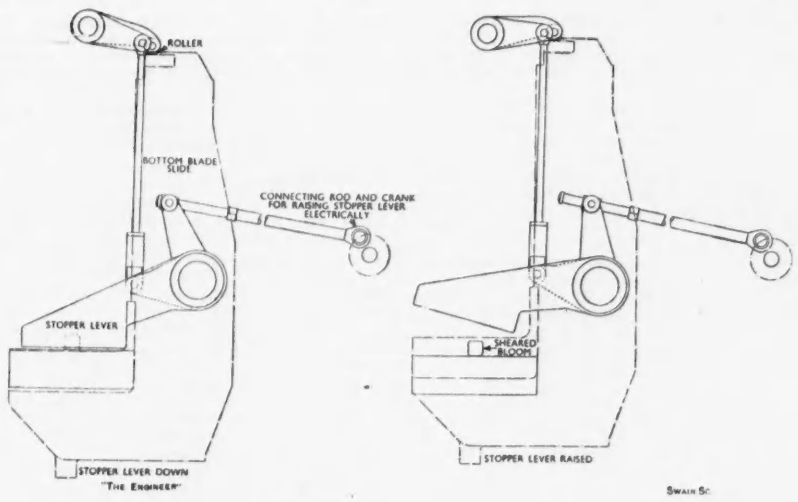


FIG. 32—*Automatic Stopper Gear.*

In this position the shock absorber is solid and therefore raises the bottom blade holder by approximately 1in. The object of this is to allow the clamp to grip the bloom between the bottom blade and itself without any pressure coming on the roller gear. At the same time, this ensures a space between the top blade and the roller gear, so that immediately the cut is completed the sheared bloom can proceed.

The further rotation of the cam shaft now pulls the connecting-rod towards it. The triangular toggle plate rotates about the pin in the bottom blade holder. (The distance piece required to take up the horizontal motion due to angular movement can be ignored for purposes of description.) The pin in the top blade holder comes down the same distance as the connecting-rod moves. The link connecting the toggle plate to the clamping plunger moves only half this distance, and hence the lever proportions, being 2 to 1, the clamp itself moves the same distance as the top blade holder.

This movement continues until the clamp reaches the bloom. In the top of the clamping plunger is a spring top blade holder. This force is transmitted to the spring in the top of the clamp plunger.

The position of the clamp relative to the bottom blade is now fixed. The toggle plate therefore ceases to rotate about the pin in the bottom blade holder and starts to rotate about the pin in the top blade holder. It can be shown that were it to rotate about any other point the distance between the bottom blade holder and the clamp would have to decrease. Thus the top blade holder remains stationary and the bottom blade holder and the clamp will ascend at the same speed. At this point all moving parts are suspended from the shaft driving the clamp situated at the top of the shears. Were the shears to be arrested in the middle of a cut the stress in the spring on the clamp plunger would be equal to the weight of the moving parts. The stress produced when shearing the bloom can be clearly seen to come on the top and bottom blade holder and the toggle plate. The connecting-rod exerts a stress equal to the shearing force.

When the cut is completed the process is exactly reversed. The shock of the arrival of the bottom blade holder on the base-plate is taken by the oil-filled spring shock absorber shown.

The gearing of the shears is lubricated by pressure oil passed through filters. The remainder of the shears has pump-fed grease lubrication. The stopper gear, Fig. 32 and Fig. 28, is electrically driven by a screw and nut. The stopper head is lifted by the upward movement of the bottom blade and it was intended that the sheared bloom should clear the stopper head before it started to come down. But the roller gear is not quite fast enough, so the electric lifting gear has to be used as well, otherwise the head comes down on the bloom before it has got away.

The crops, when sheared, fall through an opening in the roller run made by two hinged rollers, and down a chute into one of three cast steel buckets fitted with yokes so as to be automatic in tipping. The yoke pivot is below the centre of gravity when the bucket is full and above it when empty. The table on which the bucket stands can be rotated so that an empty bucket goes under the chute and a full one can be hoisted up the shaft. The hot bloom ends are then tipped into openwork wagons made of rails bent into U form.

An ingot destined for the continuous mill only has a crop taken from the front and back and then goes in one long length to the mill. The ingots for the section mill are cut into sixteen 8ft. lengths and are then pushed off the roller gear by an electric pusher on to the oscillating transfer bed.

The pusher, Fig. 29, is driven by cranks. During the forward stroke the crank pins are above the centre line of the crankshaft. A shaft between the connecting-rods has two rollers running on cams, the contour of which keeps the pusher head, which is on the end of the connecting-rods, just level with the transfer bed. On the return stroke the crank pins are below the centre line of the crankshaft and thus raise the pusher head in the air over the next bloom on the roller run.

The oscillating transfer, Fig. 30, is very soundly constructed to allow for expansion. No levelling has been necessary, since it was built. There have, however, been two slight difficulties with it. It was soon found that if the bed was full, *i.e.*, if there were about three blooms in front of each line of fingers, the motor was fully loaded and would not push any blooms out on to the dead bank beyond. This dead bank has now been replaced by a live one and the trouble no longer occurs. The other trouble was that the fingers were all too close a fit. The whole bed would work perfectly when cold, but once it got hot some fingers would stick down. The line of blooms would then be slewed round till they finally fell off the bed. This was not an easy matter to put right, as the whole bed would have to be dismantled to remove the fingers and ease them. As a temporary measure the back end of all the fingers has been weighted by welding on a small piece of billet.

Operation.—The system in use in this mill for following the steel through the mill in ingot form to the finished billet is a simple one. It was decided to use runner boys, not a pneumatic tube, for transporting the "flimsies."

Every cast when stripped is passed over a weighbridge and the weight of steel and number of ingots recorded. This is reported to the mill office and the plan clerk on Form A. The steel is then pushed into the soaking pit

TABLE II.—*Times of Individual Movements and Reductions of Area, 40in. Blooming Mill.*

Rolling 3½-ton ingot to 5-inch × 5-inch bloom. Carbon content, 0·32 per cent.

Groove Operation	Time, seconds	Mean sectional area, sq. in.	Reduction, per cent	Pass diagram, to scale
Ingot		420		
Pass 1	1·0	408	3	
Rev'se	1·0			
Pass 2	1·1	376	8	
Turn	5·3			
Pass 3	1·5	315	16	
Rev'se	1·0			
Pass 4	1·7	301	4	
1 Turn	5·4			
Pass 5	1·5	285	5	
Rev'se	1·0			
Pass 6	2·5	258	10	
Rev'se	1·0			
Pass 7	1·6	238	8	
Rev'se	1·0			
Pass 8	1·4	216	9	
Turn	5·3			
	33·3			
Pass 9	4·0	187	13·5	
Rev'se	1·1			
Pass 10	2·0	146	22	
2 Turn	3·5			
Pass 11	3·0	125	14·5	
Rev'se	1·2			
Pass 12	2·5	109·5	12·5	
Turn	4·2			
	21·5			
Pass 13	6·0	78·6	28	
3 Rev'se	1·0			
Pass 14	4·0	64	18·5	
Turn	6·1			
	17·1			
Pass 15	6·4	47·9	25	
4 Rev'se	1·8			
Pass 16	6·0	36	25	
Turn	6·4			
	20·6			
Pass 17	6·7	30·2	16	
Rev'se	1·2			
5 Pass 18	7·0	26	14	
Turn	7·3			
Pass 19	5·2	25	4	
	27·4			

Total time = 119·9 seconds.

"THE ENGINEER" SWAIN Sc.

TABLE III.—*Times of Individual Movements and Reductions of Area, 40in. Blooming Mill.*

Rolling 3½-ton ingot to 5-inch × 5-inch bloom. Carbon content, 0·18 per cent.

Groove Operation	Time, seconds	Mean sectional area, sq. in.	Reduction, per cent	Pass diagram, to scale
Ingot		420		
Pass 1	1·0	408	3	
Rev'se	1·4			
Pass 2	1·0	376	8	
Turn	5·1			
Pass 3	1·1	310	17	
1 Rev'se	1·4			
Pass 4	1·4	275	11	
Rev'se	2·0			
Pass 5	1·5	242	12	
Rev'se	1·2			
Pass 6	1·6	217·5	10	
Turn	3·7			
	22·4			
Pass 7	2·4	187	14	
Rev'se	1·5			
Pass 8	2·5	146	22	
2 Turn	3·5			
Pass 9	3·0	125	14·5	
Rev'se	1·6			
Pass 10	2·8	109·5	12·5	
Turn	3·2			
	20·5			
Pass 11	3·4	78·6	28	
3 Rev'se	1·5			
Pass 12	3·8	64	18·5	
Turn	3·3			
	12·0			
Pass 13	5·5	47·9	25	
4 Rev'se	1·8			
Pass 14	4·8	36	25	
Turn	6·7			
	18·8			
Pass 15	6·2	30·2	16	
Rev'se	1·5			
5 Pass 16	5·8	26	14	
Turn	6·2			
Pass 17	5·1	25	4	
	24·8			

Total time = 98·5 seconds.

"THE ENGINEER" SWAIN Sc.

building, where the plan clerk becomes responsible for charging it into the soaking pits, and if into stock, for the necessary marking and stocking ground.

A rolling programme is issued every week from the general office, a copy of which is received by the plan clerk as Form B. This programme gives detailed instructions as to the product, tonnage required, and distinguishing marks. In conjunction with the heater, the plan clerk arranges the order of charging the steel into the soaking pits, which in due course is sent down the mill. For every pit charged a set of six "flimsies" and one card (Form C) is prepared for distribution to the key positions along the mill. As the first ingot is drawn from a soaker a runner boy is employed to deliver the "flimsies" to the respective employees, preceding the ingot, by a margin of time, to allow for any adjustment which may be necessary. The destinations of the six "flimsies" are as follows :—

(1) Retained by the plan clerk, for his personal record.

(2) To the control cabin, from which the cogging roller man learns what size bloom is required for the continuous mill, &c.

(3) To the bloom shearer, who notes any special instructions regarding cropping, and who records on the back of his flimsy the length of scrap sheared from each ingot. This is later collected and returned to the mill office to ascertain the weight of steel passed through the continuous mill.

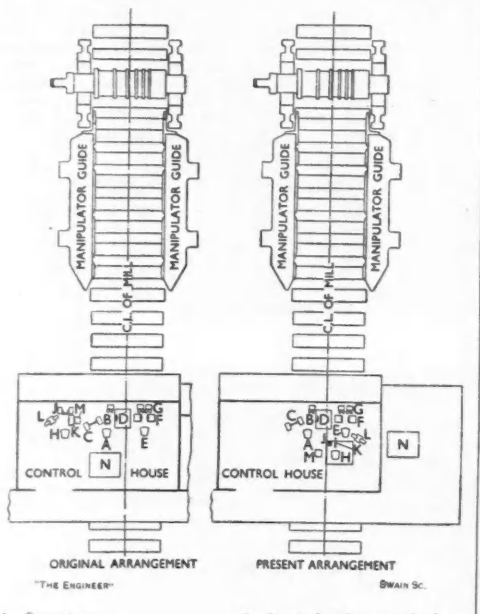
(4) This is handed to the roller man at the continuous mill, pointing out the size of billet, or weight of sheet bar to be rolled.

(5) For the operator of the "flying shear," who is responsible for cutting the material into the required lengths for each customer.

(6) Delivered to the loading bank foreman, who receives the material from the hot banks and stocks according to quality and customer.

The card is received by the recorder boy, who notes on the reverse side the number of billets recovered from each ingot. Every billet is stamped with the cast number, the stampers working in co-operation with the recorder boy.

The card is returned to the mill office immediately the number of ingots recorded thereon is accounted for, and the make and yield for each shift is gradually compiled.



A. Operator.
B. Control for continuation roller tables.
C. Controls for working roller tables.
D. Control for screw-down gear.
E. Operator.
F. Controls for manipulator guides.
G. Controls for manipulator tilters.
H. Operator.
J. Controls for breast rollers.
K. Controls for mill motor.
L. Ammeter and tachometer.
M. Overload indicator.
N. Mill motor controller resistance.

FIG. 33—*Diagram of Controls Arrangement.*

At the soaking pits the chief heater is instructed by the plan clerk which ingots he is to charge. After that he is responsible for their correct heating. He has the various settings to work to, but hitherto no pyrometric control has been used, nor has any system been installed to ensure that a reducing atmosphere is maintained during the soaking period. Generally speaking, hot ingots are in the pits for a time equal to the time since they were teemed, and cold ingots are brought up to temperature in six to eight hours. At times transferring is resorted to. This pays chiefly because the mill works on two shifts. Towards the end of a shift, perhaps one pit is hot, but empty; another has ten dull red hot ingots in. By transferring some of these ingots to the hot pit they can be rolled before the end of the shift, whereas if they were all left in one pit none of them would be.

An unusual operating feature is that as soon as an ingot has been drawn from a pit another is charged into the vacant space. In most English mills it is the practice to empty each pit completely before starting charging. Nevertheless, no ill effects have arisen from the practice at Cardiff.

There are three men driving the mill. The leading man drives the screw-down with the right hand, and the front and back working rollers with his left hand. The back working rollers are kept running in towards the mill the whole time, except when a bar is finished. He also couples the extension front and back rollers with his feet. The second man drives the right-hand manipulators with his right hand and the left with his left hand. With his left foot he works the turnover for large blooms and with his right foot the auxiliary device for small blooms. The third man drives the main motor with his right hand and switches in the front or back breast rollers with his left hand.

Two arrangements of the positions of the three men have been tried. In the first, the motor driver could not see what was happening when the bloom was entering the 5in. pass, owing to the height of the guides, and he had to rely on the manipulator driver telling him. In the new arrangement the motor driver sits above the other two and looks between them. Fig. 33 shows the arrangement of the controls diagrammatically and Fig. 31 is a photograph of the controls.

A small point of interest in the control room is that when the mill started the front of the room was of ordinary glass. Flying scale smashed it repeatedly. Armoured plate glass has been fitted and no further trouble has occurred.

Roll Pass Design.—The original design of rolls—Fig. 34—made it necessary to give all steels at least twenty-one passes to reduce the standard ingot to a 5in. by 5in. bloom. This was because the second hole was 14in. in diameter, necessitating a 14in. by 8¾in. bloom going into the 9in. hole. As this bloom had to go down to 9in. by 6¾in. to pass into the 7in. hole, it had to have at least four passes in the 9in. hole, as the reduction required was 7¼in. Four passes were also required in the 7in. hole, due to the 5in. hole being square, thus preventing any heavy draughting if over-filling was to be avoided.

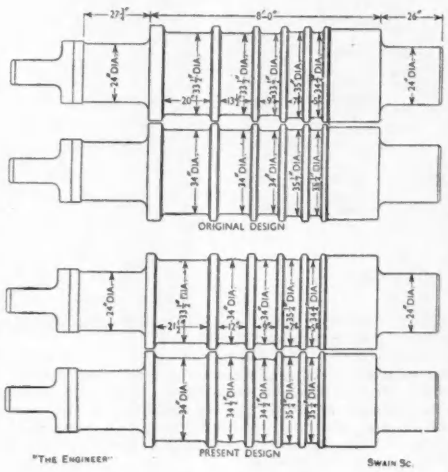


FIG. 34—*Roll Pass Design, Old and New.*

The present design permits of the standard ingot being rolled into 5in. by 5in. blooms in seventeen passes when the type of steel permits—Tables II and III. This has been achieved by reducing the 15in. hole to 12in., by splaying out the sides of the 5in. pass to 5¼in., and putting some camber in the bottom of the passes.

The most remarkable feature of the design of the rolls is the complete absence of ragging. As far as is known, no other mill in this country to-day operates entirely without ragging.

Acknowledgments.—The author wishes to express his thanks to the chairman and directors of Guest Keen Baldwins Iron and Steel Company, Ltd., for permission to prepare the paper, and to those members of the staff who co-operated in its preparation.

He also acknowledges his indebtedness to the following firms for permission to publish details of their plant :—The International Construction Company, Ltd.; Maschinenfabrik Sack G.m.b.H.; The English Electric Company, Ltd.; The Metropolitan-Vickers Electrical Company, Ltd.; The British Thomson-Houston Company, Ltd.

Canadian Engineering News.

(By our Canadian Correspondent.)

Engineering Research.

IN addition to a steady increase in the amount of testing, examination, and standardisation of instruments which the Division of Physics and Electrical Engineering of the National Research Laboratories of Canada has been called upon to perform during the last year, a number of new projects have been started. The construction of the primary standard of mutual inductance is progressing steadily. A test model has been made and work is in progress on the necessary calibration equipment. The second station for the recording of atmospheric electrical disturbances has been completed, and simultaneous records have been taken at the two stations since December 9th, 1936. Frequent records are also taken in collaboration with two stations operated by the Radio Research Board of Great Britain and with two stations in the United States.

The facilities of the optics laboratory have been greatly increased by the installation of a 3-m. optical grating. In the X-ray laboratory arrangements are being made for the installation of 600,000-volt apparatus for radiological and radiographic use. A small portable unit for radiographic purposes has been acquired and has already proved very useful. The electrical measurements laboratory has increased its resistance standards by several new units and a high-voltage condenser for use with a Schering bridge has been constructed. Further equipment for the calibration of gauge block in terms of light wave lengths has been added, and it is hoped that the laboratories will soon be in a position to carry out absolute verification on gauges up to 5in. or 6in. in length. A number of weights are being obtained for use as reference standards of mass, and are being verified by the International Bureau of Weights and Measures.

Most of the additional equipment for electrical engineering research has been built in the laboratory, and is of a special nature, as, for example, a direct-coupled amplifier to feed a Duddell type oscillograph from feeble sources of power, an adjustable oscillator capable of relatively large outputs at the lower frequencies, a special direct-current supply with adjustable taps, having an output of 1500 volts for industrial electronic investigations, and a source of high-voltage direct current. This latter unit provides the laboratory with adjustable direct current voltages up to 140,000, and has proved very successful and useful.

The performance of speed-indicating and speed-controlling equipment previously developed for use on ultrasonic sounding gear was studied. The drift of the setting of the speed controller has been gratifyingly small, and may possibly be reduced still further if necessary. The speed indicator functioned with complete satisfaction under all service conditions. While this equipment was under observation the radio direction-finder, gyroscopic compass, and amplifiers used in conjunction with the sounding equipment were also studied.

New Roasting Plant.

A new roasting building has been erected at the radium extraction plant of Eldorado Gold Mines, Ltd., Port Hope, Ontario. The new building will house sufficient equipment to triple the capacity of the old roasting plant. The decomposition of sulphides and carbonates, and the elimination of some arsenic and antimony, will be accomplished in a new Wedge roaster, with a capacity of about 5 tons per day. This roaster provides for accurate control of rate of feed, rabbling, roasting time, roasting temperature and the amount of oxidising air admitted, features which are highly desirable in the treatment of such a complex ore. The Herreshoff furnace in the former roasting plant is to be installed beside the Wedge roaster as an auxiliary, and the elevating system for the ore will be designed to feed either furnace.

In order to render the native and complex silver in the ore suitable for wet extraction by sodium cyanide or hyposulphite, the ore from the roasters must be treated with salt in reverberatory furnaces, with the production of silver and uranium chlorides. Two new reverberatory furnaces have been installed, which together will have three times the capacity of the single reverberatory in the old roast house. These furnaces, lined with ordinary firebrick, are equipped with settling chambers which are baffled to aid in the collection of some of the dust and fumes that would otherwise pass to the stack. The efficiency of the reverberatories has been further increased by the provision of combustion chambers, which were not present in the former design.

The gases from the roasting furnaces and reverberatories will be carried to a 70ft. brick stack now in the course of erection. This stack is designed to carry the gases above the level of the radium processing building, and will aid in dispersing them. A certain amount of dust and fumes will settle out in the stack, and provision is being made to remove the settlings from the bottom of the stack periodically.

Completion of the building programme on the roasting unit will see a wing added to the new building, which will replace the old roast house and provide the space for certain secondary operations. Equipment housed in this wing will include a small electric furnace and the old reverberatory furnace.

Huge Construction Programme.

The Federal Government will strike a 100 million-dollar blow at the unemployment problem during the current fiscal year. New work-creating projects will cost 40 million dollars, which is in addition to appropriations of almost the same sum provided at the beginning of the year. These works will be initiated in all parts of the Dominion. Joint work projects with the provinces, farm employment and farm rehabilitation, will take more than 6 million dollars. More than 7 million dollars is to be spent on special projects of harbour and river development, including a contribution of 300,000 dollars to the Grand River conservation project in Western Ontario. There also are substantial construction outlays for harbour improvement at Halifax, Saint John, Quebec, Montreal, Toronto, and Vancouver. Another work-producing item is 800,000 dollars for the Trans-Canada Air Lines for construction and improvement of airports along the Trans-Canada route, and 500,000 dollars to be spent in assisting municipalities to erect airports. These votes are in addition to 2,522,000 dollars contained in the main estimates for the same purposes.

Increased Power Capacity.

At Ruskin, the third link in the Alouette, Stave Falls, Ruskin chain of power plants supplying Vancouver with electrical energy, work is proceeding apace on the job of installing a second 47,000 H.P. turbine and generator. When the new generator at Ruskin is in service, it will give the British Columbia electric power plants a capacity of 285,000 H.P., besides 23,500 H.P. in steam stand-by capacity. The new unit will add 50 million kilowatt-hours a year to Vancouver's power supply. This unit is similar to a turbine and generator installed in 1930, only minor improvements having been made since that time. The same firms have the contracts as in 1930, namely, Dominion Engineering Works for the turbine and Canadian Westinghouse Company for the generator. Contractors have completed the preparatory work of concrete lining the No. 2 penstock tunnel, installing the 19ft. diameter steel penstock at the lower end of the tunnel, and back filling the space between the penstock and tunnel walls with concrete. The steel penstock itself, which ranks among the largest in Canada, was supplied by the Dominion Bridge Company of Vancouver. It contains over 150 tons of steel.

THE PARSONS MEMORIAL LIBRARY.—Books are still required for the engineering section of the Parsons Memorial Library, London House, Guilford-street, W.C.1, and the librarian will be very grateful for copies of Lives and Memoirs of famous engineers. Probably many of our readers have volumes on their shelves that they could well spare. A charming and useful home for such volumes may be found in the Parsons Memorial Library.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Iran's Steel Trade.

A considerable British trade exists with Iran, and the Report on Economic and Commercial Conditions in that country recently published by the Department of Overseas Trade, price 1s. net, contains some interesting figures. Trade with the Soviet Union improved after the signing of the Irano-Soviet Treaty in August, 1935, and with Germany increased considerably by virtue of the payment clearing agreement. Iran's exportable produce, however, would appear to have fallen short of the requirements necessary to balance her trade with these two countries. Imports from the United Kingdom in 1937 show a falling off according to provisional figures. During 1935–36, British trade with Iran amounted to £977,834 in value compared with £696,757 in the previous year, the improvement being partly due to imports of machinery, tools, and parts. Railway construction and industrial and agricultural development caused a large expansion in the imports of steel materials, rolling stock for the railway, machinery, and tools. The total imports of these materials rose from £751,450 in 1934–35 to £1,297,200 in the following year. Of the latter figure, machinery and tools accounted for £935,300, the value of the rolling stock and railway material imported being £361,900. The machinery was supplied principally by Germany, the imports from that country reaching £352,700, whilst the imports from Great Britain were valued at £196,000. Czechoslovakia sent similar material to the value of £129,400. The British imports of machinery, tools, and parts were valued at £196,015, or 21 per cent. of the total. These figures, however, do not include the imports of the Anglo-Iranian Oil Company. The Soviet Union and Germany were the principal suppliers of iron, tin, and constructional steel, and the British imports of these products, excluding the considerable non-dutiable imports of the Anglo-Iranian Oil Company, reached only £34,500 out of a total of about £519,900. It is interesting to note that, following the decline in 1934–35 of the total imports from Germany, there was a rise in the next year to a total value of £1,488,900. The increase was partly due to the payment clearing agreement of 1935, and the expansion was principally in machinery, tools, railway material, and metals. The imports from Czechoslovakia also included a considerable amount of industrial machinery.

British Iron and Steel Production.

Considerable interest attached to the production figures for May, as during that month the effects of the decline in the demand and the accumulations of heavy stocks became increasingly apparent. The figures given in the report of the British Iron and Steel Federation, however, show that production was maintained at a higher rate than had been anticipated. The output of steel ingots and castings in May totalled 957,000 tons, representing operations at approximately 81 per cent. of maximum capacity after allowance had been made for the withdrawal of a number of the older furnaces which were brought into operation to supply the demand at the height of the scarcity. The production of pig iron dropped from 661,000 tons in April to 633,900 tons last month. The latter total included 130,900 tons of hematite, a reduction of 14,500 tons on the May figures, and 374,700 tons of basic iron, a drop of 15,800 tons. The output of foundry, however, at 108,600 tons, showed an increase compared with that of the previous month of 3200 tons, whilst the production of forge iron at 16,900 tons was only 100 tons below the April figure. There were 105 furnaces in blast at the end of May compared with 111 at the end of April, seven having ceased operations and one having resumed during May. Particulars are not given in the report, but furnaces were blown out at the following works :—John Lysaght, Ltd., Scunthorpe (one); Gjers Mills and Co., Ltd., Middlesbrough (three); Colvilles, Ltd., Glasgow (one); Ebbw Vale Steel, Iron and Coal Company, Ltd., Ebbw Vale (one); and Wm. Dixon, Ltd., Glasgow (one). The one furnace blown in was at the works of the Brymbo Steel Company, Ltd., Wrexham. The following table gives the average monthly production of pig iron and steel over a period of years and the production for the past six months :—

	Pig iron, tons.	Steel, tons.
1913—Monthly average...	855,000	638,600
1920 „ „ ...	669,500	755,600
1929 „ „ ...	632,400	803,000
1934 „ „ ...	497,400	737,500
1935 „ „ ...	535,300	821,600
1936 „ „ ...	643,500	982,100
1937 „ „ ...	707,800	1,082,000
December ...	783,800	1,103,800
1938—January	761,100	1,081,400
February	693,300	1,057,600
March	714,600	1,115,800
April	661,000	938,600
May	633,900	957,000

The Pig Iron Market.

Buying interest in all departments of the pig iron market is conspicuously absent and trading seems to have developed in an accentuated form the usual quiet characteristics of the summer months. Reports from all districts tell the same story of heavy stocks in consumers' hands and mounting stocks at the blast-furnaces combined with a quiet demand. The general impression seems to be that it will take two or three months to bring these accumulations down to normal. No means exist of ascertaining the tonnage of the stocks of foundry iron in this country, but it is known that they amount to a considerable quantity. Probably if the demand were normal the position would not be regarded with the concern it now provokes; but as business in this section of the market seems to be shrinking rather than expanding, the makers are naturally disturbed by the outlook. Notwithstanding the duty of 33⅓ per cent. and the 5s. per ton loyalty rebate enforced by the producers, Belgian and French iron is being offered in this country at below the British prices. In the present condition of the market, however, these offers have met with no response. On the North-East Coast the makers are supplying deliveries from stock, and the production of Cleveland foundry iron has been curtailed. In the case of Midland irons, the decision to stabilise prices until the end of the year has not brought out much buying. One reason probably is that most of the light castings foundries are only working part of the week, and are experiencing a poor demand for their products. The best customer for the time being appears to be the heavy engineering industry, but its purchases consist chiefly of low phosphoric iron. The machine tool makers lately have taken increasing tonnages of this quality, and it is believed that the demands of the rearmament programme will probably lead to an expansion of their requirements. In Scotland new business in pig iron is almost at a standstill, and consumers are working upon their stocks. The production of hematite during May at 130,900 tons was 14,500 tons less than in the previous month; but even so, the output appears to have been in excess of the demand and stocks increased. The makers of this description have substantial orders on their books, but specifications against purchases are not altogether satisfactory. Possibly, however, the reduction in the number of furnaces producing hematite will adjust the relationship of supply to demand. The output of basic iron has also been curtailed by cutting down the number of furnaces engaged on its production, but consumption does not appear to be making any impression upon the stocks.

The North-East Coast and Yorkshire.

Since the Whitsun holidays the steel works on the North-East Coast have experienced a decline in the volume of new business even compared with the conditions prevailing at the end of May. As a result, several steel furnaces in this district have ceased working and some of the plant at the Malleable Works at Stockton of the South Durham Steel and Iron Company, Ltd., has been laid idle for the time being. Although there has been a decline in output even at the heavy steel works, this branch of the industry continues to be comparatively busy and the works have sufficient orders in hand to enable them to maintain a good rate of working for many weeks to come. They are, however, in a position to give prompt delivery and are anxiously seeking new business. There have been practically no fresh imports of foreign semi-finished steel, but the departments of the British works making this class of material are far from busy since the accumulations in the hands of users are only slowly passing into consumption. The production of joists continues on a good scale and specifications seem to be reaching the works at a satisfactory rate; but the demand for bars and other sectional material leaves a good deal to be desired. The plate mills are busy and probably this is the best employed branch of the industry. Here, again, however, the volume of new business is less than the tonnages which are being delivered. The sheet works are operating only part of their plant, and until there has been a definite improvement in export business there is little likelihood of an expansion in outputs. The re-rollers are less well off for orders than the heavy branch of the industry, and short time is prevalent. Opinions differ as to the way the stocks of light sections and bars are passing into consumption, but it is not thought that there will be any notable expansion in the demand until the end of the third quarter. Buyers are pursuing a cautious policy in the meantime, and are content when they do make purchases to limit the tonnage strictly to their immediate needs. The situation at the Yorkshire steel works has not improved since the beginning of the month, and although nearly all the works, particularly those in the Sheffield area, have large tonnages of orders on their books, the stream of specifications against these contracts has noticeably diminished. New business in acid carbon steel has become much quieter and there is less demand also for alloy steels. Disappointment is expressed at the failure of the demand for special steel from the motor car industry to develop. One or two makers report that the request for their products is well maintained, but in general the market seems to be developing unfavourable features.

Current Business.

A new factory for the manufacture of armaments is to be erected at Bridgend, Glam. Work is to be commenced immediately and the factory will be completed within eighteen months, at a cost of more than £1,000,000. A decision is expected shortly upon the question of the construction of an aero-engine works covering 50 acres at Crewe, about which negotiations have been proceeding between the Air Ministry, the Crewe Town Council, and Rolls-Royce, Ltd. Wild-Barfield Electric Furnaces, Ltd., have taken premises adjoining their Elecfurn Works, North-road, London, N.7, which will be used for demonstration and research work. An order for four large continuous furnaces has been received by British Furnaces, Ltd., Chesterfield, from an automobile company. The Office of Works has awarded contracts for boiler plant at the Royal Ordnance Factory, Blackburn, and for a fuse factory to be erected at Lower Darwen, Lancs, to Foster, Yates and Thom, Ltd., Canal Factory, Blackburn. Ferranti, Ltd., have entered into an arrangement with Wild-Barfield Electric Furnaces, Ltd., and its associated ompany, G.W.B. Electric Furnaces, Ltd., giving the latter two companies the sole right for the supply of Ferranti moving coil voltage regulators fitted with Ferranti temperature voltage relay control for furnace work. The exclusive world rights, excepting United States and Canada, for the manufacture and sale of the hydro-jet system of ash and dust handling, hitherto held by the Ash Company (London), Ltd., have been acquired by Babcock and Wilcox, Ltd., from the Allen-Sherman-Hoff Company, Philadelphia. The Ash Company (London), Ltd., will complete all contracts received up till June 30th. The Yorkshire Copper Works, Ltd., will shortly commence full operations at their new unit at Barrhead, Scotland. The Department of Overseas Trade announces that the following contracts are open for tender :—New Zealand Posts and Telegraphs Department: supply and delivery of 50 tons of hard-drawn copper wire, 200 lb. per mile, and 15 tons of hard-drawn copper wire, 150 lb. per mile, to the Department's specification No. 325 (Wellington. August 18th); South African Union Tender and Supplies Board: one 50 H.P. squirrel-cage motor and one A.C. portable welding set (Pretoria, July 7th); supply and delivery to the Department of Native Affairs: ploughs, land levellers, wagons and carts, harrows, wheel scrapers, cultivators, planters, mowers, and hay rakes (Pretoria, June 30th); Eastern Bengal Railway: closing date for tenders for superheated locomotive boilers extended to June 23rd.

Copper and Tin.

Although prices have been inclined to fluctuate this week the demand has been fairly well sustained. To a considerabe extent Japanese purchases have been responsible for the firm tone in the market, but European countries also bought good tonnages, and in this country the War Office entered the market for a substantial quantity. In America the market has developed a rather brighter tone, but buying by consumers appears to be spasmodic. On the other hand, a curtailment of production—at any rate during the summer months—appears to have been decided upon, and several large western copper mines have temporarily closed down. It is expected that this will reduce the copper reaching the market by 20,000 tons monthly. It is difficult to say to what extent American consumers are living upon their stocks, but that they have been doing so on a rather large scale has been evident for some time, and the curtailment of output may bring out a fair amount of buying. If the American market takes a definite turn for the better it would quickly exert a sentimental influence upon business in copper in European countries, and might result in the expansion in trading and the upward movement in prices which has been so long awaited by dealers in this department. There was an immediate reflection of the improvement in the electrolytic market in standard copper and a considerable amount of bear covering caused prices to advance. The rise was perhaps overdone and later profit taking caused values to fluctuate. . . . Business in the tin market has been on a small scale and is likely to remain so until details of the plan for the establishment of the Buffer Pool are made public. It is understood this will be discussed at a meeting of the International Tin Committee to be held on June 20th. The general expectation is that the Committee will decide to give a 10 per cent. quota for the Pool and a 35 per cent. quota for the market, and this would materially restrict supplies. It was perhaps in anticipation of some decision of this character that American consumers entered the market at the end of last week and made fairly good purchases. At the same time, there is a disposition to regard the American situation as unfavourable owing to the belief that heavy invisible stocks exist in the United States. Naturally, speculation is almost entirely absent, since few operators would take the risk of dealing in a market so much under control. At the same time, the general belief is that the operations of the Pool are almost certain to bring about a rise in prices.

Lead and Spelter.

The situation in the lead market does not materially change from week to week, but recently a more optimistic feeling developed and prices showed a tendency to advance. There is no doubt that consumption has declined compared with the demand of a month or two ago, but this movement is to be expected during the summer, and on the whole the total amount passing into consumption is well maintained. The belief that at the present level of prices the world's production must decrease seems to have been only partially borne out so far; but there have been reports recently of mines restricting their operations. There seems little doubt that if values continue at their present levels the higher cost producers will eventually decide to close down until the market improves. The principal consuming industries appear to be well provided with orders, and although the cable makers are not taking so much metal as a few weeks ago, they are still offering a substantial outlet, whilst the rearmament programme is providing a considerable amount of work for the battery makers which is reflected in a steady demand for lead. In spite of the decline in operations in the building trades the pipe and sheet works are also fairly busy and continue to take good quantities. The stocks in this country are said to be growing, and as imports continue on a good scale this is not unlikely. It is probable, also, that there are considerable tonnages of lead in consumers' works. The position, however, cannot be regarded as unsatisfactory whilst the demand is maintained at its present level. . . . The quiet conditions which have ruled for so long in the spelter market still prevail, and as the consuming industries appear to be taking only moderate quantities of the metal there does not seem to be any immediate prospect of a revival in demand. On the other hand, supplies are on a scale well in advance of the requirements of the market. Apparently, however, the low prices which have ruled for this metal are being reflected in a reduction in the world's output, and according to American statistics the production in April was about 8000 tons less than in March. The producers in this country are also reported to have sharply curtailed their output; and in Belgium, it is understood that steps are being taken to bring production more into line with the demand. For some time past the call for high-grade spelter which was such a feature of the situation in the earlier part of the year has declined and is now on only a moderate scale.

Current Prices for Metals and Fuels.

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from associated British Steelmakers. †Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-.

	Home.	Export.
(D/d Teesside Area.)	£ s. d.	£ s. d.
N.E. COAST—		
Hematite Mixed Nos.	6 12 6	—
„ No. 1	6 13 0	7 7 6
Cleveland—		
No. 1	5 11 6	6 2 6
No. 3 G.M.B.	5 9 0	6 0 0
No. 4 Foundry	5 10 0	5 19 0
Basic	5 0 0	—
MIDLANDS—		
Staffs— *(Delivered to Black Country Station.)*		
North Staffs. Foundry	5 11 0	—
„ „ Forge	5 6 0	—
Basic	5 0 0 to £5 5 0	—
Northampton—		
Foundry No. 3	5 8 6	—
Forge	5 5 6	—
Derbyshire—		
No. 3 Foundry	5 11 0	—
Forge	5 8 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	6 13 0	—
No. 1 Foundry, ditto	6 0 6	—
No. 3 Foundry, ditto	5 18 0	—
Basic, d/d	5 7 6	—
N.W. COAST— Hematite Mixed Nos.	6 13 0 d/d Glasgow 6 18 6 „ Sheffield 7 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS AND YORKS—	£ s. d.	£ s. d.
Crown Bars	13 5 0	—
Best Bars	13 15 0	—
MIDLANDS—		
Crown Bars	13 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	11 12 6	—
No. 4 Quality	12 2 6	—
SCOTLAND—		
Crown Bars	13 5 0	13 5 0
Best	13 15 0	13 15 0
N.E. COAST—		
Crown Bars	13 5 0	13 5 0
Best Bars	13 15 0	13 15 0
Double Best Bars	14 5 0	14 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	13 17 6	—

STEEL.

	*Home.	†Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	11 3 0	10 12 6
Tees	12 3 0	11 12 6
Joists	11 3 0	10 12 6
Channels	11 8 0	10 17 6
Rounds, 3in. and up	12 3 0	11 12 6
„ under 3in.	12 15 6‡	11 0 0
Flats, under 5in.	12 15 6‡	11 0 0
Plates, ¾in. (basis)	11 13 0	11 0 0
„ ⅞in.	11 18 0	11 5 0
„ 1in.	12 3 0	11 10 0
„ 1⅛in.	12 8 0	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	12 3 0	12 2 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 10 0
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 8 0	11 0 0
„ ⅞in.	11 13 0	11 5 0
„ 1in.	11 18 0	11 10 0
„ 1⅛in.	12 3 0	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	11 18 0	12 2 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 10 6	11 0 0
„ ⅞in.	11 15 6	11 5 6
„ 1in.	12 0 6	11 10 0
„ 1⅛in.	12 5 6	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	12 0 6	12 2 6

STEEL (*continued*).

	*Home.	†Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	11 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 8 0	11 0 0
„ ⅞in.	11 13 0	11 5 0
„ 1in.	11 18 0	11 10 0
„ 1⅛in.	12 3 0	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ¾in.	11 18 0	12 2 6
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
„ under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ¾in. (basis)	11 10 6	11 0 0
„ ⅞in.	11 15 6	11 5 6
„ 1in.	12 0 6	11 10 0
„ 1⅛in.	12 5 6	11 15 0
Un. ⅛in. to and incl. 6 lb. per sq. ft. (8-G)	12 10 0	12 2 6

IRELAND—F.O.Q.—	BELFAST.	REST OF IRELAND.
	£ s. d.	£ s. d.
Angles	11 5 6	11 8 0
Tees	12 5 6	12 8 0
Joists	11 5 6	11 15 6
Channels	11 10 6	11 13 0
Rounds, 3in. and up	12 5 6	12 8 0
„ under 3in.	12 3 0‡	13 0 6
Plates, ¾in. (basis)	11 13 0	11 15 6
⅞in.	11 18 0	12 0 6
1in.	12 3 0	12 5 6
1⅛in.	12 10 0	12 10 0
Un. ⅛in. to ¾in. incl.	12 3 0	12 5 6

‡ *Rounds and Flats tested quality; untested 9/- less.*

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. f.o.b. £ s. d.
11-G. and 12-G., d/d	14 15 0	11-G. to 14-G 12 10 0
13-G., d/d	15 2 6	
14-G. to 20-G., d/d	15 10 0	15-G. to 20-G 12 15 0
21-G. to 24-G., d/d	15 15 0	21-G. to 24-G 13 0 0
25-G. and 26-G., d/d	16 10 0	25 and 26-G. 13 15 0

South Africa, Rhodesia, Nyasaland £14; Canada £14 12s. 6d. f.o.b. basis. Irish Free State, £15 15s., f.o.q., four-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10 cwt., £2 per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.—

Home.	£ s. d.
4-ton lots and up	18 10 0
2-ton to 4-ton lots	18 17 6
Under 2 tons	20 2 6

Export; India, £18 15s. c.i.f.; Irish Free State, £18 10s. f.o.q.; General, £16 15s. f.o.b., 24-G. basis.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 20/3 to 21/6.

Tin-plate Bars, d/d Welsh Works, £7 15s.

Billets. 100-ton lots and over, 35 to 100 tons, 5/- extra: less than 35 tons, 10/- extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 17 6
„ „ „ tested	8 7 6
Basic (0·33% to 0·41% C.)	8 12 6
„ Medium (0·42 to 0·60% C.)	9 2 6
„ Hard (0·61% to 0·85% C.)	9 12 6
„ „ (0·88% to 0·99% C.)	10 2 6
„ „ (over 0·99% C.)	10 12 6
Rails. Heavy, 500-ton lots, f.o.t.	10 2 6
„ Light, f.o.t.	9 2 6

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro Tungsten	4/8 per lb. (nominal)	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 5 0	7/6
„ „ 6 p.c. to 8 p.c.	£24 0 0	7/6
„ „ 8 p.c. to 10 p.c.	£24 0 0	7/6
„ „ Max. 2 p.c. carbon	£36 0 0	11/-
„ „ „ 1 p.c. carbon	£38 5 0	11/-
„ „ „ 0·50 p.c. carbon	£41 0 0	12/-
„ „ „ carbon-free	1/- per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£18 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 0 0 scale 6/- p.u.	
„ Vanadium	14/- per lb.	
„ Molybdenum	4/9 per lb.; 5/- forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton.	
Cobalt	8/6 to 9/6 per lb.	

NON-FERROUS METALS.

(Official Prices, June 15th.)

COPPER—	
Cash	£33 18 9 to £34 0 0
Three Months	£34 2 6 to £34 3 9
Electrolytic	£38 10 0 to £39 0 0
Best Selected Ingots, d/d Birmingham	£38 15 0
Sheets, Hot Rolled	£70 0 0

	Home.	Export.
Tubes, Solid Drawn (basis)	11¾d.	11¾d.
„ Brazed (basis)	12d.	12d.

BRASS—	
Ingots, 70/30, d/d Birmingham	£31 10 0

	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	10¾d.	10¾d.
„ Brazed	12¾d.	12¾d.

TIN—	
Cash	£171 5 0 to £171 10 0
Three Months	£172 0 0 to £172 5 0
SPELTER—	
Cash	£12 6 3 to £12 7 6
Three Months	£12 10 0 to £12 11 3
LEAD—	
Cash	£13 6 3 to £13 7 6
Three Months	£13 6 3 to £13 7 6
Aluminium Ingots (British)	£100 to £105

FUELS.

SCOTLAND.

LANARKSHIRE— (f.o.b. Grangemouth)—	Export.
Navigation Unscreened	18/6 to 19/-
Hamilton Ell	17/6
Splints	20/-
AYRSHIRE— (f.o.b. Ports)—Steam	15/9 to 16/-
FIFESHIRE— (f.o.b. Methil or Burntisland)—	
Prime Steam	17/6
Unscreened Navigation	18/- to 19 -
LOTHIANS— (f.o.b. Leith)—Hartley Prime	17/-
Secondary Steam	16/6

ENGLAND.

	Inland.
SOUTH YORKSHIRE, HULL—	
B.S.Y. Hards	21/6 to 22/-
Steam Screened	19/- to 19/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/3 to 18/6
„ Second	18/-
„ Best Small	17/6
Unscreened	18/- to 19/-
DURHAM—	
Best Gas	21/-
Foundry Coke	29/- to 35/-
SHEFFIELD—	
Best Hand-picked Branch	28/- to 29/6 —
South Yorkshire	25/6 to 27/- —
Seconds	22/- to 24/- —

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	24/- to 24/6
Best Seconds	24/-
Best Dry Large	23/6 to 24/-
Ordinaries	23/6 to 24/-
Bunker Smalls	17/6 to 19/-
Cargo Smalls	16/6 to 17/6
Dry Nuts	24/6 to 26/-
Foundry Coke	37/6 to 55/-
Furnace Coke	28/- to 30/-
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	38/- to 41/-
Machine-made Cobbles	41/- to 51/-
Nuts	40/- to 50/-
Beans	33/- to 38/6
Peas	26/- to 29/6
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	20/- to 25/-

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon
Furnace Oil (0·950 gravity)	3¼d
Diesel Oil	4½d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Reconstructed Shipping.

MERCHANT shipping has for many years been struggling along under difficulties that have been aggravated by an accelerated economic decline until the situation has become so precarious as to require drastic remedies. The shorter working week for seamen obliged shipowners to employ larger crews, and the heavier costs during a period of low freights made it impossible to compete for international freights without State assistance. The introduction of the forty hours' week added to the burden of shipowners, for a declining efficiency and troubles arising out of the social reforms threw them entirely on the mercy of the State, which did what it could, with the system of maritime credits, to assist owners to renew their fleets and provide subsidies and special grants as partial compensation for the additional costs imposed upon them by the social reforms. This financial assistance was wholly inadequate and failed in its object. During the past few years only a relatively small tonnage of new ships has been acquired and hardly anything besides subsidised tonnage has been built in French yards, where the cost is about 60 per cent. higher than in foreign shipyards. Both shipowners and shipbuilders could, therefore, only look to the State for a solution of an intricate and serious problem. As already reported, the Minister of the Merchant Marine, Monsieur Chappedelaine, has evolved an ingenious financial system whereby the funds of the Credit Maritime have been enormously increased to cover the difference in the cost of construction in French and foreign yards. Owners can therefore now buy ships in French yards at the same cost as abroad. The additional credits, which are really subsidies for shipbuilding, will allow of 500,000 tons of shipping being constructed in French yards during the next three years at a cost of 1000 million francs a year. This tonnage represents about a fifth of the total merchant shipping tonnage, of which only 28 per cent. is less than ten years old, and it does not represent the amount of new shipping required to replace ships that are out of date and lag far behind in speed. All this, of course, applies to "free shipping" that is not directly subsidised by the State. Now that a big step has been made towards the reconstruction of the merchant fleet, there are proposals for the construction of a new giant liner, and the suggestions made imply that it is not intended to be a direct competitor of the "Queen Elizabeth" in size and power, but rather a ship of smaller tonnage designed on lines following the technical and commercial experience with the "Normandie," from which it appears likely to differ in many respects.

Shipowners' Difficulties.

Now that the State has provided facilities for the construction of half a million tons of shipping during the next three years, it was supposed that the plan of reconstruction would proceed smoothly, but at the last meeting of the Association des Grands Ports Français it became clear that shipowners were not generally in a position to take advantage of the facilities offered. Ships may be built, but they must be run economically, and in the present state of affairs this is regarded as impossible. The meeting was presided over by Monsieur Rio, a former Minister and President of the Commission of the Merchant Marine in the Senate. With the heavy social charges imposed on owners the cost of running ships is far above that of foreign ships, and owners look to the State to provide them with a subsidy as compensation for the difference during the whole of the time the ship is in service. They naturally argue that the State, being responsible for the present condition of things, is alone able to help the shipping industry out of its difficulties. Owners are also hampered by the dearness of money, from which they want to be relieved by the State facilitating long-term loans at a low rate of interest. Monsieur Rio pointed to another difficulty in the deteriorated efficiency of seamen under the new social system, and he affirmed that the efforts being made to finance and organise the reconstruction of the merchant fleet would avail little unless corresponding efforts were made by workers of all categories in shipping and in industries associated with shipbuilding. Since then these matters have been discussed by the Senatorial Commission of the Merchant Marine, and the Government is invited to do what is necessary to remove these remaining difficulties from the successful application of the reconstruction plan.

Charcoal Suction Gas.

Next month there is to be a congress of "forest gas" at Limoges and Clermont-Ferrand, with demonstrations of all types of vehicles running on wood and charcoal suction gas, similar to the one that was held at Blois about ten years ago, when the Government initiated a movement in favour of the fuel. For some years progress in suction gas plants and the adaptation of engines to the fuel was slow, although persistently encouraged by the Government, which freed from taxation vehicles running on suction gas, but the increasing cost of petrol has given so large a margin of economy to suction gas that it is now accepted as a practical and cheap national fuel. Makers of suction gas plants and engines have not been slow to respond to the promise of a profitable future for the charcoal fuel, the use of which is being made compulsory on a certain percentage of lorries and buses employed for public services, and suction gas equipments and methods of adapting engines to run on the fuel are now giving quite satisfactory results from the point of view of reliability and economy. The forthcoming congress is likely to mark a decisive stage in the progress of this fuel, when its standardisation and supply will be taken into account. The Government has already settled upon a standard form and quality of compressed charcoal, for the manufacture of which it is proposed to lay down a hundred factories in different parts of the country so that supplies can be delivered cheaply over particular areas. At the recent Paris Fair the Ministry of Agriculture had a large exhibit devoted to the different aspects of charcoal distribution for motor lorries.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton-buildings, Chancery-lane, W.C.2, 1s. each.

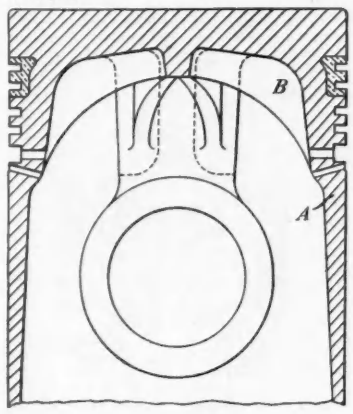
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

483,993. September 28th, 1936.—PISTONS FOR INTERNAL COMBUSTION ENGINES, Specialloid, Ltd., and Eric Bradley Graham, Friern Park, North Finchley, London, N.12.

It has been found in connection with pistons of internal combustion engines that certain advantages are secured by furnishing in the structure of the piston a ring of cast iron or steel of an austenitic character, particularly in the case of pistons for compression-ignition engines. The invention is based upon the observation that an unbroken ring of cast iron or steel of an austenitic character extending above the top of the compression ring and incorporated in the structure of the piston, in consequence of the relatively low rate of heat conductivity of austenitic iron and steel, and of the fact that it becomes surrounded by a film or skin of oxide in the casting of the body of the piston, operates to baffle the direct heat flow from the head of the piston to the topmost and the next succeeding row of grooves in which compression rings are arranged. A further observation on which the invention is based is that the heat baffling effect may be secured by the incorporation in the piston of an insert at a position above the groove of the topmost compression ring even when the insert does not form a carrier for the upper compression ring or compression rings. Generally, the cast iron or steel of an austenitic character employed in accordance with the invention has a thermal coefficient of expansion of 0·000016 to 0·000019 per deg. Cent., and generally not greater than 0·000018, while the light metal alloy may have a coefficient o expansion to heat at 20 deg. Cent. of 0·000022 per deg. Cent. In the construction shown the piston A has a ring or annulus B of austenitic cast iron, which is provided with grooves for the reception of the compression rings. Another construction has a ring of the iron let into the piston head above the topmost compression ring and penetrating to some depth into the head.—*April 28th*, 1938.

Nº483,993

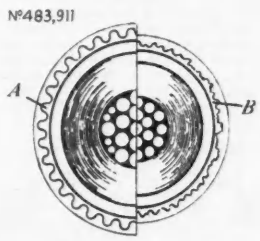


ELECTRICAL APPLIANCES.

483,911. October 19th, 1936.—IMPROVEMENTS IN ELECTRICAL INSULATING TAPE, Siemens Brothers and Co., Ltd., of Caxton House, Tothill-street, Westminster, London, S.W.1; and Albert Henry Roberts, of 35, Eaglesfield-road, Plumstead, London, S.E.18.

This invention relates to electrical insulating tapes in which an absorbent material—for example, paper—forms the base for an insulating impregnant such as a bituminous compound. Insulation of this kind usually employs an impregnated flat tape, which is wrapped about an electric cable. As it is necessary that a substantial layer of impregnant should be retained about the cable and thin patches of impregnant due to squeezing during wrapping avoided, considerable care is necessary in wrapping the tape, particularly in the case of an electric cable where the electric and chemical protection provided by the tape is an important factor for the preservation and safety of the cable. The object of the invention is to provide an insulating tape in which the impregnant is retained about the article and thin patches due to squeezing are avoided. In the invention the absorbent tape, before impregnation, is provided with lateral corrugations, whereby some extensibility is provided, and the impregnant is applied so that a substantial amount of it is retained in the hollows of the corrugations which may be even and regularly spaced, as shown at A, or uneven and irregular as at B, this form being preferable, as it not only makes the tape more extensible, but holds more impregnant and assists in preventing flow of the impregnant. The corrugations are preferably comparatively small in depth. The corrugated tape may be usefully employed as a protection for the lead sheath of an electric cable over which it is wrapped, and the tape may be mechanically protected by a further wrapping consisting of armouring wires.—*April 19th*, 1938.

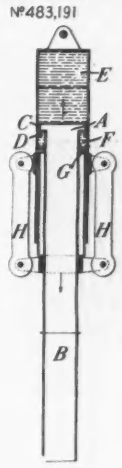
Nº483,911



MISCELLANEOUS.

483,191. April 23rd, 1937.—SHOCK ABSORBERS, Etablissements Ch. Faure-Roux, Saint Chamond, Loire, France.

Nº483,191



In the embodiment shown, the cylinder has a movable piston A secured to a tubular piston rod B. The piston forms with the cylinder an annular passage C of small section. In the cylinder is provided an annular stop D, upon which the piston rests in the idle position. The piston forms in the cylinder two chambers E and F, of which the chamber F is limited by an auxiliary piston G. The piston G extends around the piston-rod in the form of a jacket. At its lower end are mounted one or more forked brackets with which is connected one end of the extensible device H, consisting of rubber. The other end of H is connected with the cylinder. When the load is brought upon the piston-rod the piston moves in the pump barrel and displaces a quantity of liquid which flows through the passage C into the chamber F, thus moving back the auxiliary piston G. The extensible devices H are subject to a tension which is equal to the load brought upon the piston G.—*April 13th*, 1938.

483,452. August 27th, 1937.—EVAPORATORS FOR REFRIGERATING MACHINES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

It is an object of this invention to provide an improved evaporator of the flooded type for refrigerating machines. The evaporator is made of inner and outer sheet metal portions provided with indentations or corrugations forming the cylindrical header A adjacent the upper ends of the sheets, a plurality of separate U-shaped depending conduits B, a sinuous conduit C, a manifold D, and a plurality of ducts connected to the manifold and the lower portions of the U-shaped passages B. The upper ends of the U-shaped passages all communicate with the lower portions of the header A and are all arranged substantially in longitudinal alignment. The sheets are bent to form side walls and top and bottom walls, providing upper and lower surfaces for supporting freezing trays and the like. Refrigerant circulating passages B extend downwardly from the header A within the side wall and across the bottom wall, and the sinuous conduit C extends in part across the top wall and in part within the side wall. The sheets are secured together around their edges. and between the indentations by welding or brazing; the front and rear edges of the sheet E being folded over the respective edges of the sheet F in the manner indicated. Liquid refrigerant is admitted to the evaporator and enters a passage G which communicates directly with the sinuous passage C and the refrigerant

Nº483,452 Fig.1

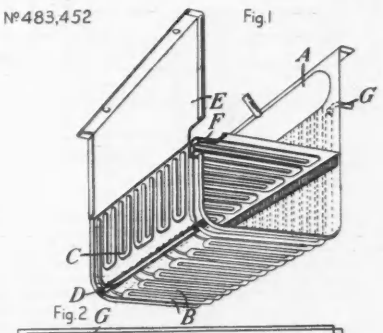
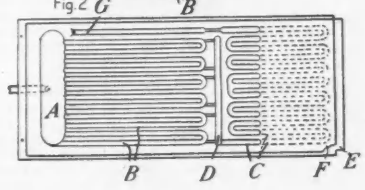


Fig.2



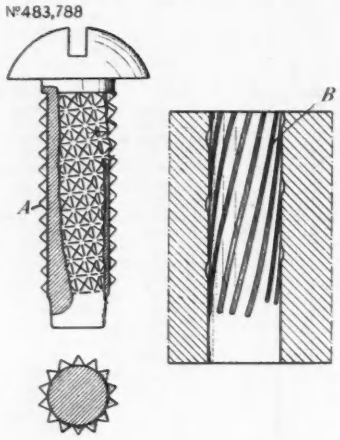
circulates therethrough and flows to the manifold D. According to the invention, in order to induce a positive circulation of liquid refrigerant in a predetermined direction through each of the U-shaped conduits, each of the ducts from D is arranged to inject refrigerant directly into the base of one limb of a U-shaped conduit, to produce a flow through that limb of the conduit upwardly to the header A. The resultant injector action produces a positive flow of liquid refrigerant through each of the U-shaped passages, liquid refrigerant re-circulating from the header downwardly through the other leg of the passage; a rapid circulation and re-circulation in all U-shaped passages is thereby provided. During the operation of the evaporator refrigerant is admitted and flows through the sinuous conduit C and thence to the manifold D. Some of the refrigerant flowing through C is vaporisable by the absorption of heat. The vaporised and liquid refrigerant flows from the manifold D in substantially equal amounts through the ducts and into the passages B. Since each of the ducts directs refrigerant upwardly into only one leg of the U-shaped passage with which it communicates, the direction of flow of refrigerant in each passage is definitely predetermined and minimum turbulence of liquid refrigerant in the header is assured at all times. Liquid refrigerant vaporised within the passages B by the absorption of heat collects in the header and is withdrawn through suction conduits.—*April 20th*, 1938.

483,788. June 18th, 1937.—IMPROVEMENTS IN SCREW NAILS, Bechert and Co., Drahtstifte-Schrauben- und Stahlindustrie-Aktiengesellschaft, Zatec/Saaz/, Czechoslovakia; and Johann Meersteiner, Zatec/Saaz/, Czechoslovakia.

This invention comprises a screw nail with stud-like projections on the outer surface of the nail, characterised in that these projections constitute thread cutting elements, the bases of which lie on the intersections of helical lines, the one having the pitch of a normal screw thread and the other a steep pitch approximating to the perpendicular relative to the first line. On driving in these screws, the outer layers of which, together with the projections A, are hardened, the steep-pitched helical grooves B are formed in the usual way in the sides of the previously bored hole. By slightly rotating the screw after it has been driven in the material of the wall of the hole between the steep grooves will be cut into by the thread cutting projections A whereby the screw will be prevented from being withdrawn in an axial direction. This additional cutting of the projections into the wall of the hole also affords protection against

the screw working loose by vibration. The screw nail may, however, also be used like an ordinary self-cutting screw. In the constructional example shown the thread-cutting projections A are regular pyramids, the summits of which lie along lines which trace the ridges of relatively fine and steep-pitched

Nº483,788

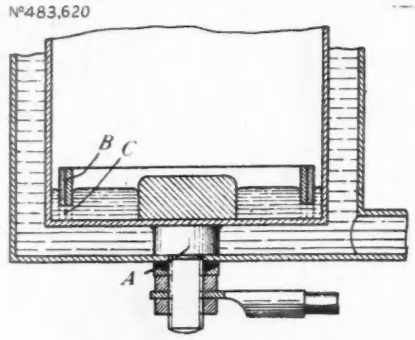


screw threads respectively. The projections may, however, be so shaped that their points are displaced relatively to the centre of their bases in the screwing direction, thus increasing their thread-cutting action.—*April 26th*, 1938.

483,620. July 5th, 1937.—MERCURY CATHODE DISCHARGE TUBES, N. V. Philips, Gloeilampenfabrieken, of Emmasingel, Eindhoven, North Brabant, The Netherlands.

This invention has for its object to arrange the mercury surface of cathode discharge tubes and the tube parts by which it is bounded in such a manner that it is rendered difficult for the cathode spot to traverse a considerable path on the mercury cathode surface before it finds an opportunity of anchoring. The bottom of the cathode vessel has arranged on it concentrically with the anchoring body A an annular anchoring body B

Nº483,620

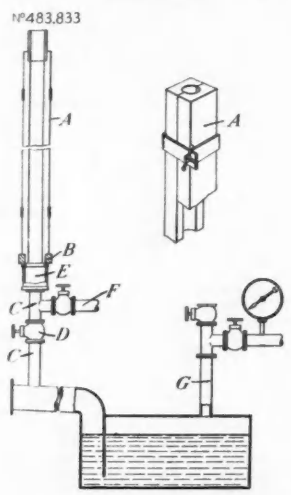


made internally of nickel and externally from molybdenum and having formed in it below the surface of the mercury cathode recesses C through which the mercury that drops down from the vessel wall can again reach the annular channel between the bodies A and B. The cathode spot has between these bodies, both internally and externally of the annular mercury surface, an excellent opportunity of anchoring, but the annular space outside the body B is made very narrow and is bounded by surfaces of material having no anchoring effect, so that the discharge is practically prevented from settling therein.—*April 22nd*, 1938.

483,833. October 30th, 1936.—MAKING FLEXIBLE TUBES AND PIPES, Superflexit, Ltd., and William Horace Grint, Trading Estate, Slough, Bucks.

The main object of the invention is to enable a flexible smooth bore tube to be produced which is simple and at the same time is of a construction such that it can be made in all normal sizes. When it is desired to make according to the invention an elastic or flexible tube capable of resisting the action of petrol, benzole, oils, or other hydrocarbons, a solution of polyvinyl alcohol or a

Nº483,833

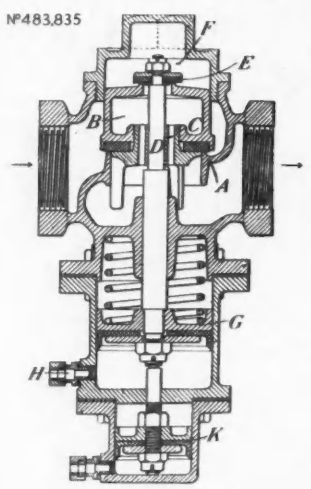


derivative thereof may be used as the medium. A former A of square cross section and made with a cylindrical bore is mounted on a frame B. The former is split longitudinally and the two parts held together by removable metal straps. The tube is formed by pumping the medium, in a liquid state, upwards inside the former, allowing the medium to recede, and passing hot air through the former to dry the layer of medium that has adhered to the bore. The process is repeated until a tube of the required wall thickness has been formed. After each layer has been deposited it is advisable to allow a little time for the layer to settle into a smooth state prior to drying. The medium, in a liquid condition, is stored in a tank which is connected to the lower end of the former A through a pipe C containing a valve D, and a sight glass E. A branch pipe F containing a valve extends laterally from the pipe C. When the medium is caused to flow up and down inside the former the valve in F is closed, while the valve D is open. By admitting compressed air to the top of the tank through a pipe G, medium is caused to flow upwards through the pipes to the former. Then, when the compressed air is released from the tank, the medium recedes. To dry the layer of medium deposited inside the former the valve D is closed, while the valve in F is opened. This permits hot air from a source with which the pipe communicates to pass upwards through A. The apparatus can be constructed so as to enable a number of tubes to be formed simultaneously, in which case a number of formers are arranged in communication with the conduit from the tank. —*April 27th*, 1938.

483,835. November 3rd, 1936.—IMPROVEMENTS IN VALVES, Ivor Gwynne Perrett and Automatic Controls, Ltd., 239, Acton-lane, London, W.4.

The present invention provides for a restricted opening of a valve in cases where relatively small quantities of water or other liquid are required to pass, for example, when a large flow is necessary for the initial filling of a container, after which a small flow is sufficient for maintaining the desired level in the container while part of the liquid escapes by an overflow device. As illustrated, the valve comprises a casing having an internal dividing wall A, which forms a seating for the main valve member B. The latter is made in two parts of different diameter screwed together. The boss C has an axial hole through which an operating stem D can slide freely for an initial movement, after which a shoulder on the stem lifts B from its seating. A number of holes are formed in the boss so that the interior of the hollow piston B is in constant communication with the outlet side of the valve. The cylindrical portion of the hollow valve piston has a slight clearance in its surrounding guide cylinder F. A pilot valve E engages with an annular seating on the end of B, the initial movement of the operating stem lifting E from its seating to allow free passage of liquid from the cylinder F through B to the outlet when the pilot valve is open. A piston G secured to the opposite end of D works in a cylinder fitted to the flanged end of the valve casing. A spring inserted between

Nº483,835

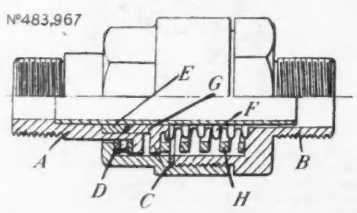


G and the bottom wall of the casing tends to return the operating ram and maintain both the pilot valve E and the main valve B in the closed position. When air, water, or other fluid is admitted through the connection H to act on G it moves to open the pilot valve E, thus allowing water to escape from the space at the end of the guide cylinder F, the pilot valve E allowing the water to run out through the holes in C faster than it can leak through the clearance round B and as soon as the pressure in F has fallen sufficiently the valve stem D is able to lift the main valve member in the usual way, the water then flowing directly through the main valve. Upon release of pressure from piston G the spring first closes E and then moves the hollow piston B until the main valve member is closed. The rate at which this movement occurs is governed by the clearance between the hollow piston B and the cylinder F. The valve is provided with an auxiliary operating ram or piston K arranged to work in a cylinder mounted coaxially with the main ram cylinder. K is mounted adjustably upon a piston-rod which engages with the end of the valve stem D. The ram K is operated by a separate supply of pressure fluid admitted to the outer end of its cylinder, the resulting movement causing its piston-rod to open the pilot valve E and allow the water to escape from the guide cylinder, as above described, and thus allowing the valve stem to lift the main valve member B to a limited extent and permit the passage of a small amount of liquid.—*April 27th*, 1938.

483,967. October 8th, 1937.—IMPROVEMENTS TO PIPE COUPLINGS, The Power Flexible Tubing Company, Ltd., of Derby Works, Finsbury Park, London, N.4.

This invention refers to unions or couplings for tubular conduits intended for conveying fluids under pressure and of the kind comprising two body elements maintained in assembly as by a sleeve, a packing compressing member being arranged at the end of an elastic corrugated tube open to the interior of the conduit so that the said member is subject to an axial force by the pressure existing in the conduit. In the accompanying engraving the two body elements A and B of a union are adapted

Nº483,967



by their screw-threaded outer ends for the securing of the ends of the tubes to be continued and a sleeve C serves to secure the elements together. The element A is provided at its inner end with an outwardly directed flange, between which and an inwardly directed flange on the sleeve is disposed a thrust bearing D. The element A is prolonged by a tubular extension about which the mouth of the element A leaves an annular space in which a plastic packing E is located. The element B of the union comprises a wall portion having a relatively large internal diameter and is provided with an external thread upon which the sleeve C screws. Within the sleeve is an elastic metallic sleeve F with a thin, annularly corrugated wall which at one of its ends is fixed, by welding, to the body of the element B. At the other end of the sleeve there is fixed an annular spigot G of such diameter and thickness that it can enter the annular throat of the element A. The end surface is inclined so that the packing is partly pressed against one of the lateral walls of the throat. Near its end which is located outside the throat of the element A the spigot has an outwardly extending flange, against which bears a helical spring H housed in the space between the wall and the sleeve with its other edge bearing against a transverse annular surface of the element of the union. When a pressure exists in the conduit this pressure is exerted also within the elastic sleeve to which the fluid penetrates through the annular gap between the element and the tubular extension. The pressure acting on the interior of the elastic sleeve tends to cause expansion and consequently elongation thereof. The spigot is thus clamped upon the packing and the clamping force becomes greater as the pressure in the interior of the conduit is raised, so that the tightness of closure of the union is always proportional to the pressure of the fluid in the conduit. In another design the tubular extension is unitary with the element A of the union and does not penetrate into the interior of the element B. Further, the anti-friction means between the flange of the element and the sleeve is constituted by a ring of hard metallic wire.—*April 28th*, 1938.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INST. OF BRITISH FOUNDRYMEN.—Annual Conference, at Bradford.

NEWCOMEN SOC.—Summer meeting in the Lake District.

SATURDAY, JUNE 18TH.

NORTH OF ENGLAND INST. OF MINING AND MECHANICAL ENGINEERS.—Neville Hall, Newcastle-on-Tyne. "Mechanised Safety," Captain Stanley Walton Brown; "The Use of Pneumatic Picks as an Aid to Coal-getting," H. E. Morgan. 2.30 p.m.

MONDAY, JUNE 20TH, TO WEDNESDAY, JUNE 22ND

INST. OF HEATING AND VENTILATING ENGINEERS.—Summer meeting at Bournemouth.

TUESDAY, JUNE 21ST, TO FRIDAY, JUNE 24TH.

INTERNATIONAL ENGINEERING CONGRESS.—At Glasgow.

TUESDAY, JUNE 21ST, TO SATURDAY, JUNE 25TH.

BRITISH WATERWORKS ASSOC.—Twenty-seventh annual general meeting and conference at Plymouth.

TUESDAY, JUNE 21ST.

INST. OF CIVIL ENGINEERS: PORTSMOUTH, SOUTHAMPTON AND DISTRICT ASSOC.—Visit to the Winchester by-pass road works (County of Southampton).

WEDNESDAY, JUNE 22ND.

INST. OF ENGINEERS-IN-CHARGE.—Visit to Cadbury Bros., Ltd., Bournville works and village.

MONDAY, JULY 4TH, TO FRIDAY, JULY 8TH.

INST. OF ELECTRICAL ENGINEERS.—Summer Meeting at South Midland Centre.

WEDNESDAY, JULY 13TH, TO FRIDAY, JULY 15TH.

INST. OF MINING ENGINEERS.—Summer meeting at Manchester.

THURSDAY, AUG. 25TH, TO FRIDAY, SEPT. 2ND.

WORLD POWER CONFERENCE.—Vienna sectional meeting.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. J. KEIR, B.Sc., A.M.I.E.E., has joined the London sales staff of Bull Motors. Mr. Keir was previously on the London sales staff of Lancashire Dynamo and Crypto, Ltd.

MR. H. O. FARMER has resigned his position as chief engineer to Petters, Ltd., and has joined Alan Muntz and Co., Ltd., of Heston Airport, Hounslow, in order to take charge of the development of Pescara free piston engines

MESSRS. HIGHFIELD AND ROGER SMITH, consulting engineers, of 36, Victoria-street, London, S.W.1, and Unitas House, Birmingham, have taken into partnership Mr. Ernest Ambrose, M.I.E.E., and Mr. Arthur L. Coward, A.M.I.E.E.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., informs us that it has appointed Dr. F. W. Haywood, Ph.D. (Lond.), B.Sc. (Hons.) Lond., to the position of chief metallurgist to the company to take charge of the new research department nearing completion. Dr. Haywood is at present engaged with I.C.I. (Fertiliser and Synthetic Products), Ltd., at Billingham.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

MARRYAT AND SCOTT, Ltd., London, have received a contract for nine 2-ton automatic goods lifts and two automatic passenger lifts for the Admiralty at the new Naval Base, Singapore.

THE ISMAILIA VALVE COMPANY, London, has received an order for a 36in. "Ismailia" tidal flap valve with by-pass for small flow, for the work being carried out for the River Ancholme and Winterton Beck Catchment Board by Holst and Co., Ltd., 1, Victoria-street, S.W.1.

LAUNCHES AND TRIAL TRIPS.

LA CARRIERE, steamship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Trinidad Leaseholds, Ltd.; dimensions, length 410ft., breadth 53ft. 9in., depth 30ft. 9in., deadweight 8340 tons. Engines, triple-expansion; constructed by Wallsend Slipway and Engineering Company, Ltd.; launch, June 2nd

Printed on thin paper for overseas circulation.

The Engineer

LONDON, FRIDAY JUNE 24, 1938.

PUBLIC NOTICES.

Air Ministry.

APPLICATIONS are INVITED for CIVILIAN POST of DRAUGHTSMEN, GRADE II, at various Royal Air Force Stations. Candidates should have had a good technical training, Engineering Workshop and Drawing Office experience.

Salary: Up to 82s. a week, depending on qualifications and experience. Promotion to Draughtsman, Grade I (£220-10-£260-12-£330 per annum), is governed by merit as and when vacancies arise.

Grade II appointments are non-pensionable. Draughtsmen, Grade I, and above are eligible for consideration for appointment to pensionable posts in the event of vacancies arising on the permanent establishment.

Application should be made on a form to be obtained (quoting reference No. B.505) from the UNDER SECRETARY OF STATE, Air Ministry, S.2.D. (S.205), Adastral House, Kingsway, W.C.2, to whom it should be returned. 4447

Applications are In-

VITED for the APPOINTMENT for a probable period of two years of experienced DESIGNING and DETAILING DRAUGHTSMEN for Reinforced Concrete and General Civil Engineering Work. Salary offered £6-£8 per week, according to qualifications and experience.—Apply by letter, giving age, qualifications, and experience, to CHIEF ARCHITECT, H.M. Office of Works, Room 65A, 3rd Floor, Storey's Gate, S.W.1. 4892

Civil Engineering

DRAUGHTSMEN for General Civil Engineering Work REQUIRED in South Wales. Approximate period of employment 2 years. Salary £4-£6 per week, to suitable candidates, according to qualifications and experience.—Apply by letter, giving age, qualifications, and experience, to RESIDENT ENGINEER, H.M. Office of Works, Watertown Lane, Bridgend, Glam. 4891

Mechanical Draughts-

MEN REQUIRED, preferably with experience on any of the following types of work :—

War Stores.
Commercial Vehicles (Chassis or Trailers).
Jigs and Tools.

Applicants should have had not less than three years' Workshop Experience. Age 21 years to 30 years. Preference given to ex-Service men, other things being equal. Pay up to 82s. per week, according to ability and experience. Posts are non-pensionable, but, subject to suitable qualifications entrants are eligible for consideration for promotion and for appointment to the pensionable establishment should vacancies arise.

Application forms obtainable by postcard from CHIEF SUPERINTENDENT OF ORDNANCE FACTORIES (Advt. No. 225), Royal Arsenal, Woolwich, S.E.18. 4895

Crown Agents for the

COLONIES.
COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POST :—

ENGINEER REQUIRED by the Government of Hong Kong for the Public Works Department for three years, with possible permanency. Salary £545 a year, rising to £950 a year. A higher initial salary may be offered to well-qualified candidates. Residential allowance of £50 a year payable from the 4th to the 17th year of service and thereafter £100 a year. Free passages and, if married, for wife and children not exceeding four persons. Leave on full salary. Candidates, age 23-35, must have passed Sections A and B of the A.M.I.C.E. examination or hold some other recognised civil engineering qualification; have had two years' practical experience on the erection, running and maintenance of pumping stations, be good draughtsmen and land surveyors, and be capable of taking charge of the erection of pumping plants by direct labour.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank London, S.W.1, quoting M/5396. 4915

War Department.

DIRECTORATE OF FACTORIES.

APPLICATIONS are INVITED for CIVIL ENGINEERING POSTS at Woolwich or on Factory Sites in Lancashire or South Wales.

Salaries according to qualifications and experience within a range of £350-£500.

Posts temporary for duration of work, which is expected to last not less than 18 months.

Applicants must have good general experience in Planning Factory and Workshop Buildings, and knowledge of Estimates and Quantities. Should hold P.A.S.I., A.M.I.E., or equivalent qualifications.

Application forms obtainable by postcard from the CHIEF SUPERINTENDENT OF ORDNANCE FACTORIES (Advt. No. 224), Royal Arsenal, Woolwich, S.E.18, to be lodged in 10 days. 4894

War Department.

JUNIOR LECTURER REQUIRED on the Electrical Side of the Mechanical and Electrical Engineering Branch of the Military College of Science, Woolwich. Candidates should preferably be under 35 years of age, and possess a University Honours Degree. A knowledge of the Principles and Practice of Radio Communications is desirable. Annual salary scale, £300 by £18 to £400. The minimum of £300 will be reduced by £18 for every year by which the Junior Lecturer on appointment falls short of the age of 25.

The Federated Superannuation System for Universities will apply.

After 5 years' service as Junior Lecturer the successful candidate may expect, if he serves so long, advancement to the Lecturer Grade on an annual salary scale of £400 by £18 to £454 by £25 to £600, if certified competent to perform the highest duties of the higher grade.

Increments are granted annually, subject to approved service.

Successful candidate will be required to take up his duties as early as possible.

Ex-Service candidates given preference, other things being equal.

Application form obtainable by postcard from the COMMANDANT, Military College of Science, Red Barracks, Woolwich, S.E.18, to be lodged not later than 8th July, 1938. 4893

The Engineer

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PUBLIC NOTICES.

The University of Sheffield.

ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

The Council are about to APPOINT an ASSISTANT LECTURER in MECHANICAL ENGINEERING. Salary £350 per annum. A somewhat higher initial salary might be paid to a man possessing exceptional qualifications. Further particulars may be obtained from the undersigned, with whom applications should be lodged by July 4th.

W. M. GIBBONS,
4839 Registrar.

University College, Notting-

HAM.
TECHNICAL TRAINING COURSE.

A One-year Course of Training for Graduates (men) wishing to qualify for teaching posts in Technical Institutions, other than Junior Technical Schools or Evening Classes, arranged by the Department of Education of University College, Nottingham, begins in September, 1938. The course has been approved experimentally by the Board of Education, and students admitted to it will receive grants towards tuition and maintenance in accordance with the official Regulations for the Training of Teachers. Graduates in Engineering, Mining, Economics, and Commerce who have had at least twelve months' appropriate industrial or commercial experience are eligible for admission. The number of approved places in the course is strictly limited, and application for forms and particulars should be made immediately to the DEPARTMENT of EDUCATION, University College, Nottingham. 4920

North-Western Polytechnic.

PRINCE OF WALES ROAD, KENTISH TOWN, LONDON, N.W.5.

Principal: Dr. J. G. DOCHERTY, M. I. Mech. E.

The Governors of the North-Western Polytechnic invite APPLICATIONS for the POST of FULL-TIME GRADUATE ASSISTANT to Teach General Engineering Subjects in the Day Technical School and Evening Department.

Applicants must be Graduates of a British University, and have had considerable Teaching Experience, and be prepared to take an Active Part in the Social Activities of the Polytechnic. Industrial Experience is essential and Corporate Membership of an Institution desirable.

The salary is in accordance with the Burnham Scale, and the successful candidate will be expected to commence duties on the 1st September, 1938.

Application forms may be obtained by sending a stamped, addressed foolscap envelope to the CLERK TO THE GOVERNORS, North-Western Polytechnic Prince of Wales Road, N.W.5, and must be returned not later than the 6th July, 1938. 4878

PUBLIC NOTICES.

MANCHESTER MUNICIPAL

College of Technology.

(Faculty of Technology in the University of Manchester.)

APPOINTMENT OF ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

The Governing Body invites APPLICATIONS for an ASSISTANT LECTURESHIP in MECHANICAL ENGINEERING in the College of Technology, with the title and status of Assistant Lecturer in the University of Manchester.

Salary £300 per annum.

Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester. The last day for the receipt of applications is Monday, 4th July, 1938.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

B. MOUAT JONES,
4876 Principal of the College.

UNIVERSITY OF LONDON.

King's College.

FACULTY OF ENGINEERING.

CIVIL, MECHANICAL, ELECTRICAL and CHEMICAL ENGINEERING.

COMPLETE COURSES OF STUDY, extending over three years, are arranged for the Engineering Degrees of the University of London and/or for the Diploma and Certificate of the College.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING.

Professor of Civil Engineering and Dean of the Faculty :—
C. H. LOBBAN, D.Sc., M. Inst. C.E.
Professor of Mechanical Engineering :—
S. J. DAVIES, D.Sc., Ph.D., Wh.Ex., M.I. Mech. E.
Reader in Mechanical Engineering :—
E. GIFFEN, M.Sc., Ph.D., A.M.I. Mech. E.

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PUBLIC NOTICES.

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PATENTS AND DESIGNS ACTS, 1907 TO 1932.

Notice is Hereby Given that

THE STERLING CORPORATION, of 7, West Tenth Street, Wilmington, Delaware, United States of America, SEEK LEAVE to AMEND the SPECIFICATION of LETTERS PATENT No. 422,599, granted to John Flammang and Percy Louis Bowser, for an invention entitled "A Piston Casting Machine." Particulars of the proposed amendment were set forth in No. 2579 of the "Official Journal (Patents)," published on 22nd June, 1938.

Any person, or persons, may give Notice of Opposition to the amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C.2, within one calendar month from the date of publication of the said Journal.

M. F. LINDLEY,
4904 Comptroller-General.

Borough of Watford.

NEW WATERWORKS, 1935, CONTRACT NO. 5.
PUMPING PLANT.

The Corporation invites TENDERS for the SUPPLY and ERECTION of ELECTRICALLY OPERATED WATERWORKS PUMPING PLANT, consisting of Duplicate Sets of Centrifugal Bore-hole and High-lift Pumps of 66,000 gallons per hour capacity each, complete with Electric Motors, Control Gear, Valves, Pipe Work, &c.

Drawing, form of contract, and general conditions may be seen, and copies of the drawing, specification, and form of Tender obtained, on application to Mr. W. W. Newman, M. Inst. C.E., F.S.I., Borough Engineer, on payment of a deposit cheque for £5 5s., payable to the Watford Corporation, which will be returned on receipt of a bona fide Tender and the return of all documents supplied.

Tenders, in sealed envelopes, endorsed "Tender for New Waterworks, 1935, Contract No. 5, Pumping Plant," are to be delivered to the undersigned not later than 11 a.m. on Wednesday, 13th July, 1938.

The Corporation does not bind itself to accept the lowest or any Tender.

Only firms with considerable experience in this class of work should apply.

W. HUDSON,
Town Clerk.

Municipal Offices,
14, High Street, Watford,
20th June, 1938. 4912

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The Engineer

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Entered as second-class matter at the Post Office, New York, N.Y., December 12th, 1896, under the Act of March 3rd, 1879 (Section 397, P.L. & R.).

*** READING CASES, *to hold two copies of* THE ENGINEER, *cloth sides and leather backs, can now be supplied at 4s. 9d. each, 5s. 3d. post free.*

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next due, August 26th.

ADVERTISEMENTS.

The charges for Classified Advertisements is 1/- per line up to one inch—minimum chage 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

Postal Address, 28, Essex-street, Strand, London, W.C.2. Teleg. Address, "Engineer Newspaper, Estrand, London." Tel., Central 6565 (10 lines).

PUBLIC NOTICES.

Borough of Cleethorpes.

FIRE-ENGINE.

TENDERS are INVITED for the SUPPLY of a New FIRE-ENGINE (fitted with 50ft. Escape) of a capacity of 600/800 gallons per minute.

Forms of Tender, together with all further particulars, may be obtained from the undersigned, to whom Tenders should be submitted on or before the 7th July, 1938.

ALBERT S. BARTER,
Town Clerk.

Council Offices,
Cleethorpes,
17th June, 1938. 4879

County Borough of Southend-on-Sea.

TO HEATING CONTRACTORS AND ELECTRICAL CONTRACTORS.

MUNICIPAL HOSPITAL, ROCHFORD, ESSEX. (ENGINEERING WORKS.)

The Corporation of Southend-on-Sea propose to invite TENDERS from suitable Contractors for the EXECUTION of the undermentioned WORKS in connection with the Erection of a Municipal Hospital now proceeding at Rochford, Essex:

(a) The Supply and Erection of Central Boiler Plant, Heating, Domestic Hot and Cold Water Supplies, Kitchen Equipment, Fire Services, and Works incidental thereto.

(b) A Complete Electrical Installation, comprising Standby Generating Set, Power and Lighting Wiring, Lifts, Electric Cooking, Telephones, Wireless, Staff Locators, and other Auxiliary Services.

The Hospital Buildings consist of a large Nurses' Home, Children's Block, Maternity Block, Separation Block, Tuberculosis Block, Block for Pneumo-Thorax, Administration Buildings (including Offices, Resident Medical Officers' Quarters, Stores, Staff Dining-rooms, and a large Kitchen), Boiler-house, Mortuary, and Admission Block, together with other Incidental Buildings.

Contractors desirous of tendering should apply in writing to the undersigned at his office, Municipal Buildings, Southend-on-Sea, not later than 9th July, 1938, giving particulars of similar works carried out by them with dates and values of contracts.

Only contractors of repute who are able to satisfy the Corporation of their ability to execute the contracts should apply.

The contractors selected to tender will in due course be furnished with the appropriate plans and documents, and they will be required to deposit with the Corporation a fee of Five Guineas, which will be refunded upon receipt of a bona fide Tender and the return of all loaned documents. No remittances should accompany the preliminary applications.

The Corporation do not bind themselves to accept the lowest or any Tender.

R. G. Baxter, Borough Engineer; Frank W. Smith, A.R.I.B.A.; Leslie Turner, Consulting Constructional Engineer; Wingfield-Bowles and Partners, Consulting Heating Engineers; E. W. Dorey, Consulting Electrical Engineer; and Widnell and Trollope, Quantity Surveyors.

H. J. WORWOOD,
Town Clerk.

Town Clerk's Office,
Municipal Buildings,
Southend-on-Sea,
June, 1938. 4900

Metropolitan Borough of Fulham.

FULHAM POWER STATION.

The Council invites TENDERS for ONE or TWO SECOND-HAND ELECTRIC or STEAM TRAVELLING JIB CRANES, for a gross load of about 2 tons, at a maximum radius of 30ft., with the extremity of the jib at a height not exceeding 29ft. above rail level.

The electrical equipment to be suitable for a 3-phase supply at 400 volts, 50 cycles.

Further particulars and form of Tender may be obtained on application to Messrs. Preece, Cardew and Rider, 8, Queen Anne's Gate, Westminster, S.W.1.

Tenders must be delivered to the undersigned not later than 10 a.m. on Wednesday, 6th July, 1938.

The Council does not bind itself to accept the lowest or any Tender.

WILFRED TOWNEND,
Town Clerk.

Town Hall, Fulham, S.W.6.
17th June, 1938. 4903

Port of Beira.

SEAGOING STEAM TUG BOAT.

TENDERS are INVITED for a TWIN-SCREW SEAGOING STEAM TUG of 750 I.H.P., delivered at the Port of Beira, Portuguese East Africa.

Conditions of contract and general particulars regarding the vessel can be obtained from the Consulting Engineers for the Port, Messrs. C. S. Meik and Halcrow, MM. Inst. C.E., 16, Victoria Street, Westminster, S.W.1, on payment of a cheque for £10, which will be returned on receipt of a bona fide Tender.

Tenders, with drawings, all in duplicate, are to be delivered to the CONSULTING ENGINEERS by Noon on the 18th July, 1938. 4913

The Assam - Bengal Railway

COMPANY, Limited, is prepared to receive TENDERS for:—

300 AXLES FOR CARRIAGES AND WAGONS.

Specification and Tender form may be obtained at the Offices of the Company, 56, Victoria Street, S.W.1. A fee of £1 1s. is charged for each specification, which cannot be returned.

Drawings may be had at the cost of the Tenderer by application to Messrs. Hodges, Bennett and Co., Ltd., 78, Queen Victoria Street, E.C.4.

Tenders must be delivered at the Company's Offices not later than Noon on Friday, the 1st July, 1938.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
W. H. J. GORE,
Secretary.

16th June, 1938. 4871

FOR SALE.

The Conservators of the River Thames

have FOR SALE a STEAM BUCKET DREDGER.

Built in 1879 by Messrs. Hunter and English.
Hull of iron.
Length overall, 68ft.
Breadth, 12ft. 3in.
Draught, 3ft.
Minimum depth for dredging approximately 4ft.
Maximum depth for dredging approximately 12ft.

The craft will be sold as it lies at the Conservators' Wharf, Riverside Works, Fordbridge Road, Sunbury-on-Thames, Middlesex.

Offers to be submitted in a sealed envelope marked "Dredger," and addressed to the CONSERVATORS OF THE RIVER THAMES, 2/3, Norfolk Street, Strand, London, W.C.2, and to be received at their offices by not later than first thing on Thursday, 17th July, 1938.

Conditions of Sale can be obtained from the Engineer, Thames Conservancy, 2/3, Norfolk Street, Strand, W.C.2. 4874

Tyne Improvement Commission

DREDGING PLANT.

The Tyne Improvement Commissioners invite TENDERS for the CONSTRUCTION and DELIVERY in the Tyne of ONE SINGLE-SCREW STEEL GRAB DREDGER with a hopper capacity of 6000 cubic feet.

Copies of the form of Tender, conditions of contract, and specification may be obtained on application to the undersigned on payment of a deposit of £2 2s., which will be returned on receipt of a bona fide Tender.

Tenders, in sealed envelopes, addressed "The Chairman, Tyne Improvement Commission," and endorsed "Tender for Grab Dredger," must be delivered at the undermentioned offices not later than Noon on Saturday, the 20th day of August, 1938.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
General Manager and Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne, 1.
22nd June, 1938. 4897

PUBLIC NOTICES.

Borough of Chepping Wycombe

WATER ENGINEER'S DEPARTMENT.

APPLICATIONS are INVITED for the APPOINTMENT of ENGINEERING ASSISTANT at a salary of £300-10-225. A car allowance will be paid in connection with the post.

Candidates should have held a similar position in another Water Undertaking and have had experience in the Design and Lay-out of Plant and Buildings for Waterworks purposes. They must also be good Draughtsmen and competent Surveyors.

The successful applicant will be required to contribute to the Corporation's Superannuation Fund and to pass a medical examination.

Particulars of appointment and list of duties can be obtained from, and applications endorsed "Engineering Assistant," accompanied by copies of three recent testimonials, should be forwarded to, the undersigned not later than 1st July, 1938.

S. YOUNG, A. Inst. W.E.,
Borough Water Engineer.

70-71, Easton Street,
High Wycombe,
Bucks. 4880

City of Durban.

APPOINTMENT OF DEPUTY CITY AND WATER ENGINEER.

APPLICATIONS are INVITED for the POSITION of DEPUTY CITY and WATER ENGINEER for the City of Durban, Natal, South Africa. The grade for the position is £1500-£37 10s.-£1736-E, subject to the Council's Scheme of Deflation of Salaries and Wages. The appointment will be in terms of the Council's General Conditions of Service and Leave Regulations, and the commencing salary will be at the minimum of the grade.

Applicants must be under the age of 45 years.

The applicant must be a Corporate Member of the Institution of Civil Engineers, or possess a Degree in Civil Engineering.

The Departmental activities coming under the control of the City and Water Engineer at present include:—

PUBLIC WORKS, embracing Roads, Reinforced Concrete and Structural Steel Construction, Storm Water Drainage, Sewerage, Housing, Surveys, Town Planning, Beach Restoration, and General Development.

PARKS AND GARDENS, entailing Lay-out and Control of all Parks, Gardens, and Open Spaces.

BEACH MANAGEMENT, which includes Control of Bathing and General Pleasure Amenities.

STREET CLEANING AND CONSERVANCY, the executive side of Public Health Arrangements dealing with Street Cleaning, Night Soil and Rubbish Removals and Cemeteries.

WATERWORKS, including the Administration of all Works and Estates pertaining to Water Supply.

The successful applicant will be required to undergo a medical examination by a nominee of the Council.

Applications, stating age, qualifications and experience in full, and accompanied by COPIES of not more than three testimonials and supporting documentary evidence of qualifications and satisfactory state of health, must reach the office of the Town Clerk, Durban, South Africa, not later than Friday, 15th July, 1938.

Personal canvassing for the appointment is prohibited and proof thereof will disqualify a candidate, vide Council's Standing Order No. 1.

E. B. SCOTT,
Town Clerk.

Town Clerk's Office,
Municipal Buildings,
Durban,
11th May, 1938. 4650

County Borough of Northampton.

Consequent on certain promotions, a VACANCY exists for an ENGINEERING ASSISTANT on the Staff of the Water Engineer and Manager, at a commencing salary of £260 per annum, rising (subject to satisfactory service) by annual increments of £10 to a maximum of £300 per annum.

Applications are invited from candidates, not more than 35 years of age, who have had some previous experience in Water Engineering. They should have a sound knowledge of Surveying, Levelling, and General Waterworks Construction, and should be neat and expeditious Draughtsmen.

The post is designated under the Local Government and Other Officers' Superannuation Act, 1922, and the successful candidate will be required to pass a medical examination before being appointed to the position.

Forms of application may be obtained on forwarding a stamped, addressed envelope to the undersigned, to whom they should be returned not later than the first post on Saturday, 9th July, 1938.

W. R. KEW,
Town Clerk.

Guildhall, Northampton,
June, 1938. 4899

County Borough of Tynemouth.

WATER DEPARTMENT.

APPLICATIONS are INVITED for the APPOINTMENT of ENGINEERING ASSISTANT at a commencing salary of £350 per annum, increasing by annual increments of £25 to £400, subject to satisfactory service.

Candidates must be Associate Members of the Institution of Civil Engineers or have passed part of their examinations, and have experience in the Design, Calculations, and Details for Reinforced Concrete Work for Large Service Reservoirs.

The position is designated under the Local Government and Other Officers' Superannuation Act, 1922, and the selected candidate will be required to pass a medical examination.

Applications, stating age, experience, and qualifications, accompanied by copies of three recent testimonials, must be delivered to the undersigned not later than 10 a.m. on the 28th June, 1938.

Canvassing, directly or indirectly, will be disqualified.

Dated this 14th day of June, 1938.

FRED G. EGNER,
Town Clerk.

14, Northumberland-square,
North Shields. 4859

Government of the Punjab, India.

APPLICATIONS are INVITED from British Indian subjects (or subjects of certain Indian States) of the Muslim or Sikh communities, for TWO APPOINTMENTS of ASSISTANT EXECUTIVE ENGINEER in the Punjab Service of Engineers, Class I, Irrigation Branch.

Permanent pensionable appointments, subject to two years' probation. Pay (monthly) Rs. 300, rising by annual increments of Rs. 25 per mensem to Rs. 700, with prospects of further advancement.

Candidates must have attained the age of 21 years, and must not have attained the age of 25 years on the 1st August, 1938. They must possess one of certain University Degrees or other prescribed qualifications and must be trained as Civil Engineers. Experience of irrigation works will be regarded as an asset.

Further particulars and forms of application may be obtained, on request by postcard, from the HIGH COMMISSIONER for INDIA, General Department, India House, Aldwych, London, W.C.2. Last date for receipt of applications 9th July, 1938. 4922

Somerset Rivers Catchment Board.

CIVIL ENGINEERING DRAUGHTSMEN REQUIRED, experienced in Plotting from Field Notes and capable of preparing Neat and Accurate Drawings and Tracings.

Salary £150-250 p.a., according to experience.

Applications, endorsed "Draughtsman," stating age, experience, qualifications, and date when free, together with copies of testimonials, and specimen of draughtsmanship, should be sent immediately to the undersigned.

T. BARRINGTON,
Clerk to the Board.

12, King Square,
Bridgwater, Somerset. 4877

PUBLIC NOTICES.

River Ouse (Yorks.) Catchment Board.

SURVEYING ASSISTANT.

APPLICATIONS are INVITED for the POSITION of SURVEYING ASSISTANT on the Board's Engineering Staff.

Candidates should have had considerable experience in Surveying, Levelling, the Preparation of Plans, and Preferably of Land Drainage Work.

Salary £225, rising to £275 per annum by two annual increments of £25.

Printed forms of application and terms of the appointment will be forwarded on receipt of a stamped, addressed foolscap envelope.

Applications, endorsed "Surveying Assistant," must reach the undersigned not later than Monday, the 11th July, 1938.

F. M. FARMER,
Clerk of the Board.

Central Bank Chambers,
Infirmary Street,
Leeds, 1.
22nd June, 1938. 4898

States of Guernsey Water-Works Department.

APPOINTMENT OF ASSISTANT ENGINEER.

APPLICATIONS are INVITED for the POSITION of ASSISTANT ENGINEER at a commencing salary of £300 p.a., rising, subject to satisfactory service, to £350 p.a. by four annual increments of £12 10s.

Preference will be given to Corporate Members of the Inst. of Civil Engineers, and applicants should have had experience in the Design, Construction, and Management of Waterworks Pumping and Purification Plant.

Applications, stating age, experience, and qualifications, and accompanied by copies of not more than three testimonials, to be delivered to the undersigned before Noon on Saturday, July 2nd, 1938.

WALTER H. MORGAN,
B.Sc., A.M.I.C.E.,
Engineer and Manager.

The Water Office,
Guernsey. 4829

SITUATIONS OPEN.

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

WANTED, ASSISTANT SUPERINTENDENT, to Supervise the Manufacture of Railway, Tramway, and other Types of Traction Motors. Must have had previous executive experience in all departments of works manufacture and production.—Address, 4842, The Engineer Office. 4842 A

WANTED, ASSISTANT to GENERAL MANAGER, to Specialise on Works Side. One having technical training and having served an apprenticeship in works. Age 25-30.—Address, 4826, The Engineer Office. 4826 A

WANTED, COMMERCIAL REPRESENTATIVE, with sound experience, to travel Midlands District for large well-established firm for sale and purchase of used, rebuilt, and new machinery, principally machine tools, power presses, sheet metal working machinery, &c. Knowledge of air compressors, pumps, hydraulic plant, Diesel engines, and electrical equipment an advantage. Position demands high standard of commercial ability and resourcefulness in dealing with wide range of high-grade engineering equipment. Applicants should state experience and salary required.—Address, 4907, The Engineer Office. 4907 A

WANTED, for India, a CHARTERED STRUCTURAL ENGINEER, holding a B.Sc. Degree or A.M.I.C.E. Must have had at least 3 years' experience in Designing with a Constructional Firm of repute. Able to Take Charge of Estimating Department, and be Responsible for Preparation of Working Drawings; 5 years' agreement. Single man preferred.—Write, giving full details of training, age, and salary required, to "Z.T.661," Deacon's Advertising Agency, 5, St. Mary Axe, London, E.C. 4887 A

WANTED, REPRESENTATIVE in England for Land Boiler Work.—Address, 4823, The Engineer Office. 4823 A

AN OLD-ESTABLISHED FIRM has an OPENING for a MAN about 25-30 who knows Varied Production and Methods, and who is ambitious of making good. Engineering Experience and sense, knowledge of men, and hard and continuous work essential. Wages £6 per week. Full particulars only are acceptable.—Address, 4868, The Engineer Office. 4868 A

ASSISTANT MECHANICAL ENGINEERS REQUIRED for service in the East. Age not to exceed 25 years. Workshop training and good technical qualifications essential.—Address, 4820, The Engineer Office. 4820 A

ASSISTANT ENGINEERS REQUIRED by Large Oil Company for service in Far East and elsewhere. Age 22 to 28, unmarried. University Degree or equivalent qualification and some practical experience in Mechanical Engineering Works essential. Salary from £450 per annum.—Write, Box "T.Z.M.," c/o 95, Bishopsgate, London, E.C.2. 8877 A

CRANE ENGINEER REQUIRED by Insurance Company for inspection of heavy cranes of all types. Good technical training and practical experience essential. Must be able to make clear sketches and calculations.—Address applications, giving age and full details of career, P1374, The Engineer Office. P1374 A

ENGINEER B.Sc., or Equivalent, Aged 26-30, unmarried, REQUIRED for India by World-wide Organisation Handling Petroleum Products. Must have good General Engineering Experience, including Running of Prime Movers. Textile Experience an advantage. Must possess sales ability.—Apply in writing, giving full details of education, training, and experience to date, stating salary required, P.D., Box 452, Sells, Ltd., Brettenham House, Strand, W.C.2. P1371 A

For continuation of Small Advertisements see page 4.

Hydraulic Pumps—Pump Unit Ltd.
25, Coptic Street, London, W.C.1.

W. G. BAGNALL, LD.
STAFFORD
London Office: 32, Victoria St., S.W. Telephone: 1882 Victoria
BUILDERS OF LOCOMOTIVES
Weighing from 3 to 50 tons, for any gauge, of Highest-class Workmanship and Materials.
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A Seven-Day Journal.

Air Registration Board.

THE first annual Report of the Air Registration Board has recently come to hand; therein the Chairman, Sir Maurice Denny, reviews the first year's work of the Board, ending on March 31st, 1938. The main body of this Report is reprinted elsewhere in this issue. The Air Registration Board was formed, it may be recalled, in February, 1937, at a time when, with the growth of air transport and private flying after the Great War, it became evident that the control of the airworthiness of civil aircraft could more properly be dealt with on lines which had been developed during many years of experience of marine transport than by a Department of State, and that such control could best be exercised by a body representative of the various interests concerned. In 1933, the Gorrell Committee, which had been appointed by the Secretary of State for Air to report on the control of private flying, recommended that a board should be established to control the airworthiness of civil aircraft. Accordingly, the Air Registration Board was formed, and to it the Secretary of State for Air, under the authority of the Air Navigation Act of 1936, has taken powers to delegate the major portion of the Air Ministry's duties in connection with the control of the airworthiness of civil aircraft. The Board is composed of representatives of aircraft constructors, owners, operators, insurers, the public interest, and pilots of commercial aircraft. It is ensured by the constitution of the Board that henceforth the control of civil aviation shall be in the hands of those whose primary interest is civil aviation. At home an organisation has already been established which enables the Board to report on any civil aircraft in the British Isles with the minimum of delay. It can deal with airworthiness, provide reports of surveys after damage to aircraft and report on the condition of any civil aircraft. Overseas the Board has established branch offices in Egypt and Singapore. It proposes to extend its activities throughout the British Empire and to make arrangements with foreign governments to facilitate the survey of British aircraft abroad.

Tube Railway Collision.

THE Minister of Transport has issued a report on the inquiry into the collision which occurred between Waterloo and Charing Cross Underground stations on March 10th last at about 8.32 a.m. In this accident one train was stationary in the tunnel when a following train collided with it at low speed and twelve passengers were slightly injured. The collision was caused by the mistake of a signal lineman who had been called to deal with a defective signal. At 7.56 a.m. an intermittent failure developed on the advance starting signal at Waterloo and a power signal lineman was sent to correct it. He cut the relay out of action and shortened the clearing distance of the block section from a normal length of 615 yards to a length of 33 yards. Although he knew he had shortened the distance he did not realise how seriously, but knew, however, that for one train actually waiting the shortening of the clearing distance was immaterial, as the relay was already in a clear position before the short circuiting of the contacts. He did not immediately complete his temporary repair and returned to the platform and allowed several trains to pass. What the lineman overlooked was the fact that ordinary platform delays might be leading to stoppage of trains in the tunnel between Waterloo and Charing Cross, and that is what actually happened. A train was stopped in the tunnel and the following train collided with its rear. Colonel A. C. Trench, in his conclusion to the report, states that the responsibility for the accident must rest primarily with the power signal lineman, who was over-confident. He had only recently been transferred from an adjoining area and had not had time to become familiar with the section. The only recommendation made is that the London Passenger Transport Board should remind its staff of the necessity for the most rigid observance of the procedure laid down in regulations for dealing with cases of defective signals.

Steel Merchants' Federation.

THE announcement that the National Federation of Iron and Steel Merchants had on June 17th adopted a constitution and elected a President and an Independent Chairman marked a further stage in the establishment of this organisation. The Federation was formed last November, and is composed of associations of iron and steel merchants covering a wide range of products. Sir Walter Jenkins, who was appointed the Independent Chairman, has had a distinguished record with the Civil Service, in which he held in succession the posts of Assistant Director, Deputy Director, and Director of Navy Contracts. Amongst the important tasks entrusted to him was that of drawing up the railway plans for naval mobilisation in 1914, in conjunction with the Railway Communications Board. Mr. Ernest B. Hall, who is the President, is well known as the head of the firm of Hall and Pickles, Ltd., stockholders and steel makers, of Manchester and Sheffield, and has been Chairman of the National Association of Iron and Steel Stockholders since its formation in 1928. In a short speech on the objects of the new Federation, Mr. Hall pointed out that the constitution provided for co-operation with the British Iron and Steel Federation and all recognised associations and organisations of manufacturers engaged in the iron and steel trades. The Federation has been formed with the object of securing agreement between associations of merchants and sections of manufacturers producing materials in which they were mutually interested. Seven of the most powerful merchant organisations of the iron and steel trades in this country have become affiliated, and it was probable that other similar bodies would join them in the near future.

The Castlecary Railway Disaster.

THE report by Lieut.-Colonel A. H. L. Mount, the Ministry of Transport's Chief Inspecting Officer of Railways, on the accident which occurred at Castlecary, London and North-Eastern Railway, on December 10th, 1937, was issued by H.M. Stationery Office on Tuesday last. The accident was caused by the collision of two passenger trains on the Edinburgh–Glasgow line, and as a result of it thirty-four passengers were killed instantaneously and one died the next day, while 179 passengers were injured. The trains involved were the 4.3 p.m. express from Edinburgh to Glasgow, which was travelling at from 65 to 70 miles an hour when it crashed into the preceding 2 p.m. express from Dundee to Glasgow, which was stationary just beyond the platform at Castlecary. The two trains were running eight minutes apart, the former two minutes late and the latter on time; snow was falling, and owing to the failure to clear it entirely from between the blades of certain facing points at Gartshore, 5¼ miles ahead, delay occurred from inability to move a lock-bar and to bolt the points concerned. This affected down traffic, and the Dundee express had to be stopped at Castlecary to await the shunting of a goods train at the next signal-box, Dullatur East. The circumstances in which the express was brought to a stand —after passing the home signal at danger—appear to have misled the signalman, and the following Edinburgh express was improperly permitted to approach the station. The Edinburgh express also overran the home signal at danger and the collision occurred 325 yards ahead of this signal. Lieut.-Colonel Mount doubts whether all the facts in detail will ever be fully established. He remarks that this accident (like that at Oakley Junction on January 21st) has given rise again to the criticism that main line rolling stock in this country is not being constructed entirely of steel, and says that it is misleading to suggest that such construction would have withstood the terriffic shock of this collision any better than the heavy steel underframes and timber bodies of the coaches concerned. He suggests that the only positive safeguard against certain classes of accident at high speed is some form of automatic train control, and recommends that the company should take early steps to reach decisions with a view to applying warning control to high-speed services on its trunk routes. He calls attention to the desirability of closer observation of the rule that a brake compartment should be marshalled next the engine.

Oil from Coal.

THE Report prepared by an Advisory Committee appointed by the Labour Party to consider the production of oil from coal has just been published. It was completed before the publication of the Report of the Falmouth Committee in February last, but differs from that Report in some of its conclusions. It recommends the development of the coal-oil industry by the State, but says that, as in all pioneer industries, there is need for inventive genius and creative ideas. While these qualities can be engaged in the service of the State, the magnet of personal profit, if it is also required, should not be ruled out. For the further development of the coal-oil industry the Report recommends the extension of the preference to home-produced light oils and proposes that the State should build, either by itself or in combination with private enterprise, one new hydrogenation plant, six plants for the synthetic process, and five low-temperature carbonising plants. That a coal-oil board of five members should operate the plants directly owned by the State and exercise a general supervision over other plants is suggested. The board would conduct the day-to-day working on commercial lines, and the Secretary for Mines would be responsible in Parliament for general policy. It is estimated that the hydrogenation plant would cost £5,000,000, would treat 660,000 tons of coal a year, employ 2000 workpeople directly and 2000 miners, and produce 45,000,000 gallons of motor spirit and other products. The six synthesis plants would cost £11,400,000, treat 1,100,000 tons of coal, give direct employment to 1500 workpeople and 3700 miners, and produce 51,000,000 gallons of motor spirit and other products. The five low-temperature carbonising plants would cost £1,250,000, treat 950,000 tons of coal, employ 1250 workpeople directly and 3500 miners, and produce 3,000,000 gallons of motor spirit, 740,000 tons of smokeless fuel, and 17,500,000 gallons of tar, which could be largely used in hydrogenation plant. The production of 100,000,000 gallons of motor spirit annually would involve an estimated loss to the Exchequer of nearly £4,000,000 a year, which would be recouped in part by a saving on the unemployment benefit and allowances of 11,500 men put into work. A final recommendation is that the Fuel Research Station should undertake a bigger programme of original work and should be given £250,000 for development and an annual income for a period of years of £250,000.

British-American Industrial Developments.

DURING the past week two announcements have been made concerning new links between British and American industrial interests, a trend, it may be hoped, which may be looked upon as a forerunner to the Anglo-American Trade Pact. On Wednesday, June 15th, speaking at the annual shareholders' meeting of Darwins, Ltd., the makers of specialised steels in Sheffield, Mr. H. L. Armstrong, the chairman of the company, stated that plans had been completed for embarking upon the manufacture of stainless steel of a special kind suitable for use in a very wide range of manufactures. To this end the company had concluded working agreements with two of the most important American companies in this special field—the Superior Steel Company, of Pittsburgh, and the Ludlum Steel Company, of Watervliet, under which Darwins will receive the benefit of the American companies' patents and technical knowledge. In addition to the manufacturing of stainless steel, the American companies were, Mr. Armstrong said, producing many other products which lay within the scope of Darwins and could profitably be made at Sheffield. As a result of the agreements, the company had avoided the necessity of experimental work, and it was able to begin production of stainless steel immediately. Under the supervision of the American companies, Darwins had, he said, erected at its Sheffield works a cold rolling strip mill of the most modern American design, the entire cost of which had been financed out of the company's own resources. It is also announced that the Adamson-Alliance Company, Ltd., with its head offices at 165, Fenchurch Street, London, E.C.3, has been formed for the purpose of combining the sales and manufacturing organisations of the steel works equipment departments of Joseph Adamson and Co., Ltd., of Hyde, Cheshire, and the Alliance Machine Company, of Alliance, Ohio, U.S.A. The firm of Joseph Adamson was founded in 1874, and has specialised in steel works cranes and charging machines. The Alliance Company was founded in 1901 and has a world-wide repute for cranes and steel works plant. The hope is expressed that the pooling of interests will be of considerable benefit in equipping the steel works of this country with plant embodying the very latest methods of handling and operation.

G.W.R. Summer Services.

IN connection with the summer train services of the Great Western Railway Company, which begin on Monday, July 4th, there will be over 700 additional trains on weekdays and 500 on Sundays. Seven new mile-a-minute or over express trains will be introduced and new and accelerated services will save a total of 585 minutes daily in the journey time of trains. On Saturdays, in addition to a number of new trains for holiday traffic, nearly double the number of weekday expresses will run to the various coastal holiday resorts. On Mondays to Fridays the Cornish Riviera, Limited, express will run non-stop to Plymouth, covering the 226 miles in 240 minutes. This service on Saturdays will be run as a group of four trains, leaving London at intervals of five minutes, the principal train making its first station stop at Par. The Torbay express will also be duplicated on Saturdays, the first part running non-stop to Torquay and the second part to Paignton. Both these express services will also be run on Sundays. The seven new high-speed runs will bring the company's total of mile-a-minute or over trains up to twenty-six, covering a distance of 2116 miles daily. Twenty-one of these runs will be over a part or the whole of the original Paddington-Bristol main line route, eight will operate from and eleven to London, and Swindon will have five of the services. The "Cheltenham Flyer" with an average start-to-stop speed of 71·3 miles an hour for the 77·25 miles' run from Swindon to Paddington, will be the fastest express on the system. The summer service will involve the running of 10,394 additional miles a day, as compared with the winter service. The company is also to rearrange and augment its cross-Channel services to Ireland and the Channel Islands.

Voltage Regulators.

No. VII.

(*Continued from page 667, June 17th.*)

THE voltage regulator (Fig. 48) made by the ASEA Electric Company, of Walthamstow, in the form developed for small and medium-sized machines belongs to the class of regulators that intermittently short circuits a resistance in the exciter field circuit. Two corresponding coils are employed, one fed by the exciter and the other by the alternator; but instead of connecting the former directly to the exciter a transformer is introduced in such a way that only variations in the exciter voltage have an influence

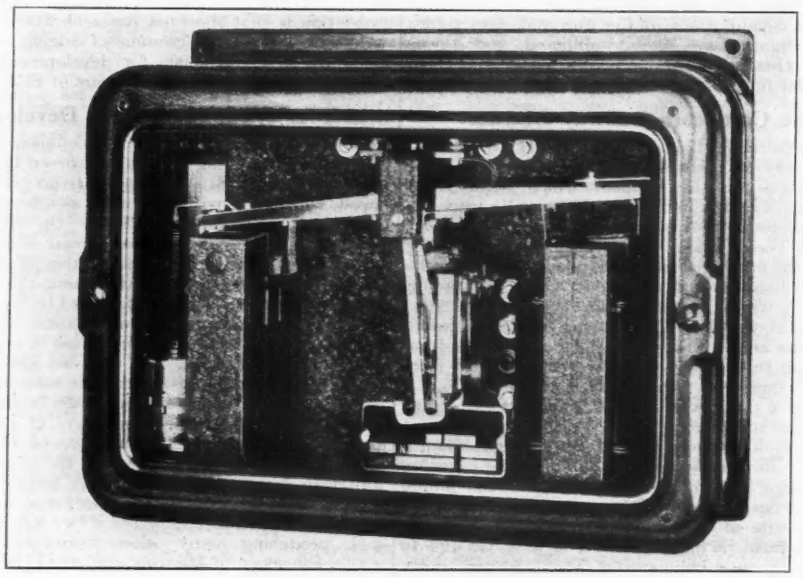

FIG. 48—ASEA VOLTAGE REGULATOR

on the regulator. In Fig. 49, A is the regulator with a lever pivoted at the centre, acted upon by an A.C. potential element connected through a potential transformer B to the generator. The lever is attached to a spring and a polarised D.C. element at the opposite end is connected to the exciter terminals through a transformer C known as the "D C" or "impulse" transformer. The exciter is self-excited, and its field winding D is in series with a resistance E, which can be short circuited by a contact actuated by the

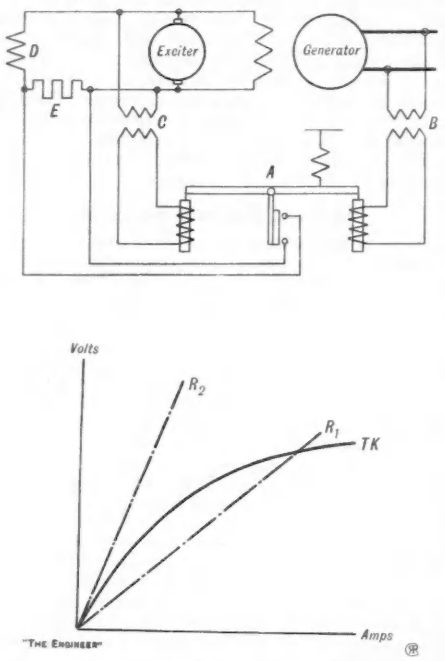

FIG. 49—CONNECTIONS FOR ASEA REGULATOR

regulator. The curve, T K, shows the relation between the exciter field current and exciter terminal voltage. Since the exciter is self-excited, the exciter field current, in the steady state, is proportional to the voltage, and the relation will be represented by a straight line R_1, when the resistance E is short circuited and another line R_2 when it is in circuit. At normal generator voltage the regulator is adjusted so that the spring and A.C. element keep the lever in equilibrium with the regulator contacts in the closed position. The voltage produced by a certain exciter field current is then given by the curve T K, and the voltage required to force this current through the exciter field winding by the line R_1. There is therefore a surplus of voltage equal to the distance between R_1 and T K, which causes the exciter voltage to rise at a rate proportional to the surplus voltage. This rise of exciter voltage causes a current to flow in the secondary of the transformer C, and the connections are such that this current tends to open the regulator contacts. If the voltage has the correct value, the contacts will be opened and the exciter voltage will then be below the value required to force the exciting current through the exciting winding, the difference being represented by the distance between the line R_2 and curve T K. The exciter voltage will therefore decrease at a rate proportional to this distance and the current induced in the secondary of the D.C. transformer takes a direction tending to close the regulator contacts.

As long as the voltage is at its normal value, the regulator is in this way kept in continuous oscillation at a frequency of approximately 3·5 cycles per second.

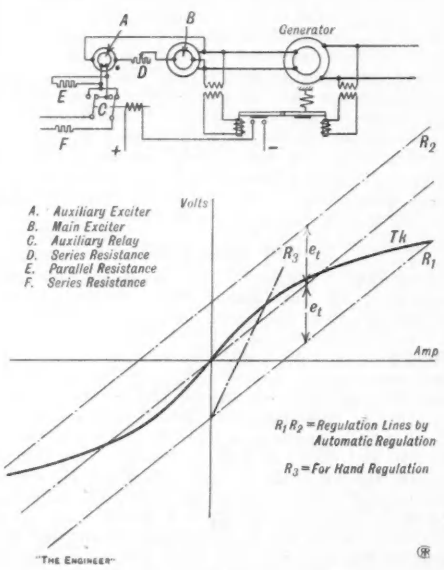

FIG. 50—REGULATING SYSTEM WITH AUXILIARY EXCITER

The variations in exciter voltage produced in this manner, which keep the regulator in motion, only amount to about a few per cent. of the normal exciter voltage, and the variations in the generator voltage are imperceptible.

If, on the other hand, a decrease in load causes the generator voltage to rise, the pull of the potential element connected to the transformer B will exceed that of the spring, so that the regulator ceases to oscillate and remains in the open contact position. The exciter voltage then begins to decrease and continues to do so until the generator voltage has almost reached its normal value. Usually, the exciter voltage will reach a value below that corresponding to the new steady state and it would be expected to cause over-regulation and oscillations in the generator voltage. But these oscillations are counteracted by the current through the D.C. element caused by the decrease in the exciter voltage which causes the contact to close before the generator pressure has reached its normal value.

During the last part of the regulation the exciter voltage will therefore again rise towards a value corresponding to the new steady state, and the constants of the D.C. transformer are so adjusted that the operation takes place practically without over-regulation of the generator voltage. This result, it is important to note, is accompanied without the use of dashpots or other damping devices which tend to reduce the speed of operation. The regulator utilises the speed obtainable with the particular exciter. From the foregoing description the action of the regulator when the voltage is suddenly decreased will also be understood.

The relation between the closing and opening times of the regulator contacts is of minor importance when considering the principle. This relation depends upon the distance between the curve T K and the regulation lines R_1 and R_2, but automatically adjusts itself without special arrangements.

An increase or decrease in the generator voltage is not caused by a change in this relation, but the regulator immediately takes a position with permanently closed or open contacts, and the regulation is immediately started with a speed which is only limited by the magnetic characteristics of the exciter and generator. Only by very small voltage variations does the regulation take place without a clearly marked period with permanently closed or permanently open contacts. Since the D.C. or impulse transformer eliminates the influence of the constant part of the

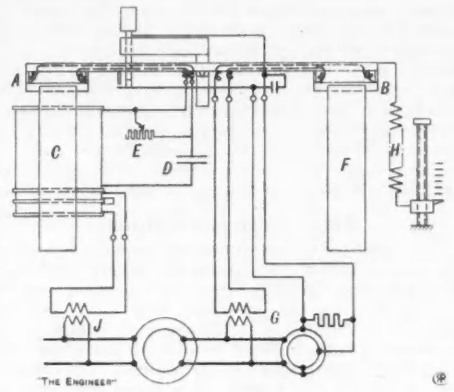

FIG. 51—DETAILS OF ASEA REGULATOR

exciter voltage, in the steady state, the regulator will oscillate about practically the same position of equilibrium regardless of the magnitude of the exciter voltage. The change in this position necessary in some regulators and the necessity for damping to avoid oscillations in the generator voltage are uncalled for in the regulator under consideration.

The speed of regulation is, as shown, proportional to the distance between the load characteristic T K and the two regulating lines R_1 and R_2, and since all the lines converge towards the origin, the speed of regulation is lower at the low exciter voltage than it is at the high exciter voltage. This fact, which is common to the ASEA and other regulators, is a disadvantage with large variations in load, and also in the case of machines operating on large high-voltage networks where on account of the large charging current at low load the generators must work with very low exciter voltage. To avoid these disadvantages, the ASEA Company has developed a regulating system giving a uniform speed of regulation within a wide range of voltage. It employs, as in other cases, a small auxiliary exciter A, Fig. 50, which is in series with the exciting winding of the main exciter B, and the regulator acts upon this exciter through the relay C in such a way that by reversing the field it gives alternatively a negative and positive voltage producing two parallel lines, R_1 and R_2, as indicated below the diagram in Fig. 50, giving a practically uniform speed of regulation from full exciter voltage through zero to full exciter voltage in the opposite direction. The average speed of regulation by large variations is obviously greatly increased and the regulator will operate satisfactorily at practically any exciter voltage, a matter of considerable importance in the case of high-voltage systems with large charging currents.

The system also makes possible simple and stable hand regulation down to the lowest values of exciter voltage. If the regulator is stopped in the position corresponding to the regulation line R_1, by means of the rheostat D, this line may, for instance, be made to take up a position corresponding to R_3, when the voltage takes the value corresponding to the intersection between R_2 and T *k*. Another possibility of hand regulation is obtained by variation in the voltage

of the auxiliary exciter which is equivalent to moving the regulation line parallel to itself.

The construction of the regulator and connections for the system of regulation described at the outset are shown in Fig. 51. The lever arm supports two moving coils A and B, the former being movable in the air gap of the A.C. magnet C, which is excited by the voltage to be regulated through the potential transformer J. To reduce the power consumption the magnet has a secondary winding connected to a static condenser D, which delivers the necessary reactive power; the regulator only consumes 8 V.A. The moving coil A is connected in series with this condenser and a shunt resistance E connected to the moving coil serves for adjusting the voltage between 90 and 110 per cent. of the normal value in 1 per cent.

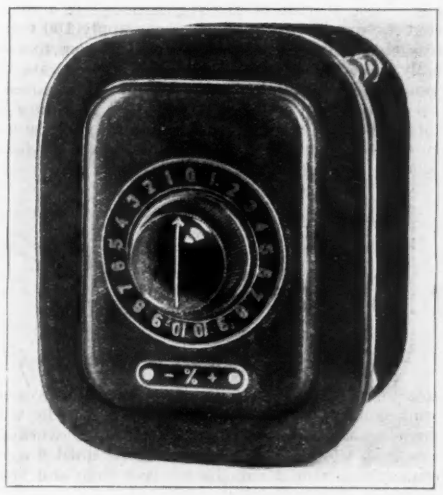

FIG. 52—VOLTAGE SETTING RESISTANCE

steps. The arrangement also makes the regulator practically insensitive to variations in frequency. The flux in the A.C. magnet at a given voltage is inversely proportional to the frequency, whereas the condenser current and consequently that in the moving coil is directly proportional to the frequency and their product which determines the electromagnetic force is thus independent of the frequency. The coil B is movable in the air gap of a permanent magnet F, and is connected to the D.C. transformer G.

Because of the bending of the curve T K, Fig. 49, the relation between the distances from this curve to the regulation lines R_1 and R_2 varies with the exciter voltage, and this is automatically compensated by the alteration in the relation between the closing and opening times of the contacts. If the spiral spring H, Fig. 51, which is attached to the

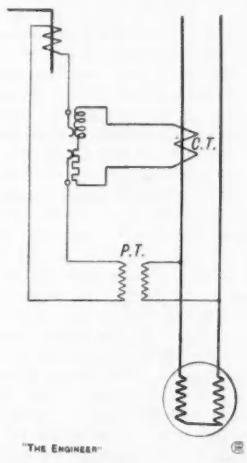

FIG. 53—ARRANGEMENT OF VOLTAGE DROP COMPENSATOR

lever arm, had its lower end fixed, the tension would vary with the exciter voltage and the main voltage would fall slightly with increasing exciter voltage. To avoid this effect the spring carries a movable weight in a cylinder filled with oil, and during the normal oscillation of the lever it acts as if it were a fixed point, but with changes in load it moves sufficiently to follow the small change in the position of the lever arm. By means of three separate weights supplied with the regulator, the setting of the standard 110-volt apparatus can be adjusted when in service in six steps of 5 volts, and by means of a spring between the oil-damped weight and a fixed screw, the setting can be continuously varied whilst the regulator is in service by about ± 5 volts. With the aid of the normal setting resistance E, the total variation in the setting can be from 77 to 133 volts. A setting resistance giving settings of ± 10 per cent. in steps of 1 per cent. is shown in Fig. 52.

The automatic voltage regulator is mounted on a metal base plate and enclosed in a dustproof casing, with a glass front. At the back of the base plate are flexible contacts for the connections which engage with contact studs on a second bakelite base plate on which the regulator is mounted and which also supports the switches for taking the regulator out of service, a changeover switch for varying the direction of current in the contacts and the adjustable resistance E, Fig. 51. The first mentioned switch has three positions. In the first position the regulator is disconnected and can be taken away from the base plate without loosening any connections. The regulation can then be carried out by hand. In the second position of the switch the A.C. magnet is connected in circuit, and it is then possible to adjust the voltage by hand to a value which brings the regulator in a state of equilibrium. If then the switch is moved to the third position, automatic regulation is brought into service smoothly, although this smooth transfer is not really necessary. If desired, the regulator can be connected even when the generator is unexcited, and the regulator can be allowed to raise the voltage to its normal value. The changeover switch for reversing the contacts can be operated during service.

For large machines and for the regulation system described with an auxiliary exciter, the regulator acts upon the resistance or auxiliary exciter through the intermediary of an auxiliary relay with contacts of sufficient closing and rupturing capacity for the current and voltage to be controlled. If it is desired to compensate for the voltage drop in lines or transformers the potential transformer is connected in series with one or more small impedances, Fig. 53, which are adjusted to correspond with the impedance of the lines or transformers, and through the impedances the secondary current of current transformers C T in various parts of the network is led. The voltage drop in these impedances is thus proportional to the drop in the corresponding parts of the network, and the voltage impressed upon

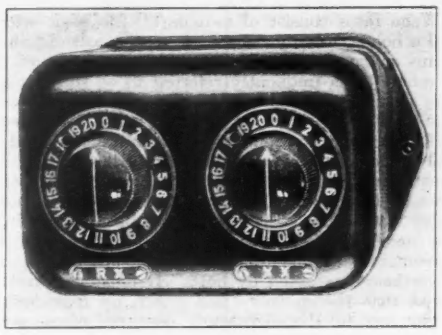

FIG. 54—VOLTAGE DROP COMPENSATOR

the regulator becomes proportional to the voltage at the point up to which the voltage drop is compensated for. That voltage will therefore be maintained constant and the arrangement gives a flexible system which can be accurately adopted to varying operating conditions. In Fig. 54 is shown a line drop compensator. Two knobs X and R are fitted to the instrument, used for adjusting the components of the compounding impedance. Associated with the knobs are dials calibrated in 1 per cent. steps from 0 up to 20 per cent.

To ensure stable sharing of the reactive load when several alternators are working in parallel, a necessary condition is, as already shown, that when the reactive load on a particular machine rises, that machine must attempt to lower its voltage at the junction point with the system, which is achieved by providing each regulator with a decompounding or negative compensation effect for reactive load. By reason of the high sensitivity of the standard 40–60 cycle ASEA regulators, this effect, the makers state, need only be slight. The instruments are provided with a small stabilising impedance built into the case and are designed to permit satisfactorily parallel operation with other high-speed regulator equipments of the same make.

The Cuenod "Simplex" automatic regulator, Fig. 55, made by Ateliers H. Cuenod S.A., of Geneva, is a direct-acting regulator with a measuring device in the form of a Ferraris motor A, fed from the circuit to be regulated and exerting a torque which is balanced under the condition of regulation, and when the rotor C is in any position by a counterweight B. The rotor spindle operates the regulating device, which consists of a small carbon wheel E, which moves over a fixed commutator F, of which the segments are connected to the steps of the regulating resistance G. The motor spindle also drives through a spiral spring S, and a train of gear wheels H, a drum J, which revolves in the field of permanent magnets K, thus providing a controlled time lag. At the ends of the rotor travel there are spring stops. The counterweight B is suspended on springs and rests at the lower end of its travel on stops M, so that in the event of a sudden failure of the motor torque no shock is transmitted to the spindle nor to the counterweight suspension. To enable the counterweight to be clamped rigidly to the case for transport, the stops are provided with screws.

As long as the quantity to be regulated is normal, the motor torque balances that of the counterweight, but if it falls below normal the action of the counterweight predominates, the spindle and wheel E rotate in an anti-clockwise direction, and resistance steps are cut out. Conversely, if the voltage exceeds the normal value, the motor overcomes the effect of the counterweight, the spindle rotates in a clockwise direction, and the wheel E inserts resistance until the original equilibrium is re-established. To avoid hunting, the time lag device is made to match the speed of regulation with respect to the time response of the machine being regulated.

When the spindle moves in either direction it transmits its motion to the spring S which, in turn,

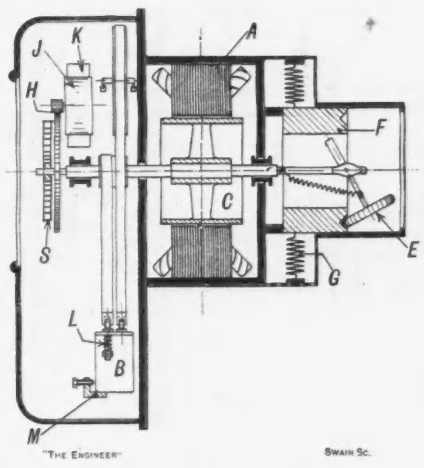

FIG. 55—CUENOD VOLTAGE REGULATOR

tends to rotate the drum J in the magnetic field, setting up eddy currents in the drum, thus resisting further movement. The degree of the delay action can be regulated by the gap between the magnets and by the strength of the spring S. The faster the wheel E and spindle tend to turn, the greater is the effect of the time lag mechanism. In the case of a regulator working at 100 volts, the apparatus begins to correct fluctuations above 100·5 volts and below 99·5 volts. The entire length of the commutator can be traversed in half a second. By means of the counterweight a change in the regulating level can be made up to a maximum of ± 5 per cent., while for a wider degree of adjustment an additional resistance is usually employed. As with other regulators, the apparatus can be adjusted so that it will only be in equilibrium for certain predetermined levels of regulation, to provide a voltage which

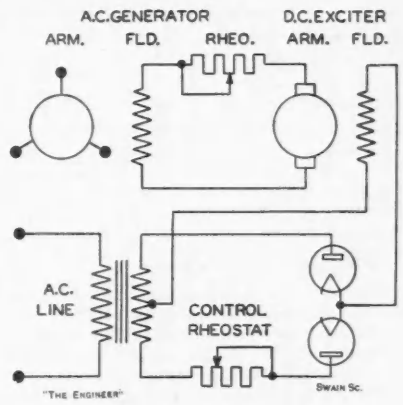

FIG. 56—HAND-CONTROLLED THERMIONIC REGULATOR

increases with load or to provide suitable regulation when alternators are operating in parallel.

In a thermionic regulator supplied by the Ward Leonard Electric Company, of Mount Vernon, New York, a single-phase, full-wave rectifier is employed to excite the exciter field. How the voltage of an A.C. could be controlled manually by using a full-wave rectifier and control rheostat is shown in Fig. 56. Although the rheostat is only connected in circuit with one valve, a change in the rheostat position will adjust the output of both valves because of the electro-magnetic coupling of the two valves provided by the shunt field winding. In Fig. 57 a grid on one of the valves takes the place of the rheostat in the anode circuit of the controlled valve in Fig. 56, and as it requires practically no power it can be used to better advantage for regulation. A grid transformer is supplied by a phase-shifting circuit containing a controlling rheostat which, as in the case of Fig. 56, is assumed to be controlled manually.

The actual circuit used in the regulator under consideration is shown in Fig. 58, although the

diagram does not include the anti-hunting circuits or the protective arrangements. The circuit is similar to that shown in Fig. 57, but the A.C. supply for the rectifier, which now acts as the regulator, is taken from the generator with its exciter supplied by the regulator. The rheostat in the phase-shifting circuit is replaced by the valve V T–2, which serves the same purpose as that of an adjustable resistance, its resistance value being determined by the amount of bias voltage which is impressed on its grid. This bias voltage is the voltage drop across R–1, which depends on the current which flows from the anode of V T–1. The electron emission from the cathode of this valve depends on the temperature of the cathode. When cold no electrons will be emitted from the

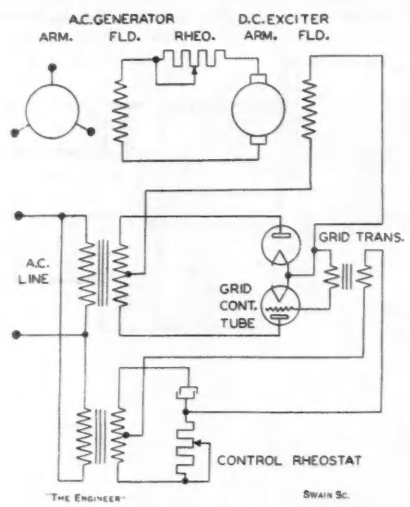

FIG. 57—REGULATOR WITH GRID CONTROL

cathode, whilst when it is hot a copious supply of electrons will be emitted. If the anode voltage on the valve is high enough, all the electrons emitted by the heated cathode will be attracted to the anode, and the maximum possible current will therefore flow in the anode circuit and this current will only vary with the cathode temperature. This principle is used to change the anode current of V T–1 in accordance with changes in the A.C. generator voltage.

The cathode of V T–1 is energised by a winding on the control transformer, which receives its supply from the A.C. generator, and any small change in the A.C. voltage is immediately reflected in the control transformer. Changes in voltage applied to the cathode of V T–1 immediately alter the cathode

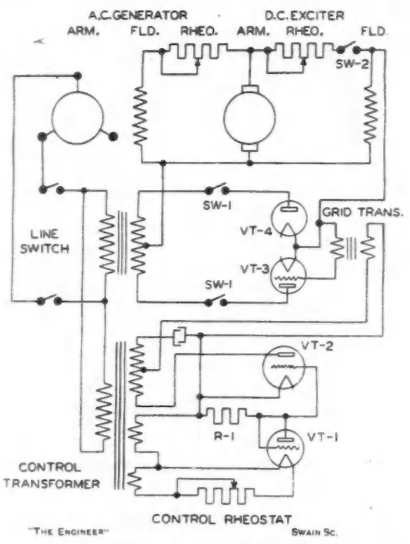

FIG. 58—AUTOMATIC THERMIONIC REGULATOR

temperature, and consequently the anode current. Within a half-cycle of the change in line voltage, the control circuit comes into action to change the output of V T–3 and V T–4, thus restoring the A.C. generator voltage to its normal value.

By operating the valve V T–1 at plate saturation the apparatus becomes very sensitive to line voltage changes. The only purpose of the rheostat in this case is to determine what generator voltage within a range of 5 per cent. of normal the regulator will maintain.

The cycle of operations is as follows:—If the generator load decreases, the A.C. generator voltage slightly increases and the voltage and temperature of the cathode of V T–1 also increase. Thus, the anode current of V T–1 increases, giving an increased drop across the resistance R–1. The negative bias voltage on the grid of V T–2 increases and reduces the plate current of V T–2, thereby increasing its resistance. The phase of the grid voltage applied to V T–3 is altered in a direction to decrease the output of both V T–3 and V T–4. Hence, the shunt field current of the exciter is reduced, the exciter armature voltage is lowered, the A.C. generator field is decreased, and the A.C. generator voltage restored to normal. Under increasing load the action of the circuit is reversed, resulting in an increased excitation to maintain normal voltage.

When a number of generators work in parallel it is desirable, as with other regulators, to provide a regulator for each machine when the apparatus can be made automatically to divide the reactive load between the generators in proportion to their respective kVA rating. Cross-current compensation requires, however, a current transformer, as previously described, and an adjustable resistance for each generator. Several exciters may, however, be operated in parallel from one regulator provided the sum of the normal field currents on all the exciters does not exceed the regulator rating and all the exciters have approximately the same saturation characteristics. It is necessary to provide a rheostat for each exciter to compensate for a small amount of dissimilarity in the saturation characteristics of the exciters. Provision may also be made as with other regulators for automatic drop compensation to maintain constant voltage at a distribution centre rather than at the generator terminals. Regulators with three standard current ratings are made, 1, 5, and 12 amperes. It is essential for the proper operation of the regulator that the exciter should be wound for a normal maximum voltage of between 100 to 125 volts. The regulator maintains the generator voltage constant within a band of ± 1 per cent. of normal for all load conditions up to the full rated kVA. The corrective action starts within $\frac{1}{2}$ cycle of the slightest change in generator voltage which is returned to the normal band within $1\frac{1}{2}$ seconds after sudden load changes up to 50 per cent. of the rated kVA, provided the prime mover speed regulation is kept within 5 per cent. and the time constant of the exciter-generator combination does not exceed 3 seconds. Field forcing is a basic feature of the regulator. For a short period the regulator may if necessary apply 160 volts across the exciter field to force the current to rise rapidly, thus greatly increasing the exciter rate of response. Similarly the reduction of field current when the load is removed from the A.C. generator is accomplished at the fastest possible rate consistent with protection to the insulation of the exciter field windings.

Engineering Wages.

By E. R. BRIGGS, M.I. Mech. E.*

WAGES in the engineering industry are regulated by the Engineering and Allied Employers National Federation in agreement with some fifty trade unions representing the workmen. On important questions affecting the industry as a whole the union representatives sit as a joint body.

Wage rates consist of two parts, the basic wage and a bonus, usually referred to as the cost-of-living bonus or war bonus. The basic wage, often quoted in amounts, is frequently referred to as the "engineer's wage," mention of the bonus being omitted. The basic wage has grown from the old pre-war wage and differs over the country and with different trades and grades of men, and is mainly dealt with by the constituent associations of the Federation with the district trade union officials concerned. Almost every town and district has its own basic wages, but few are recognised rates, that is, form a definite agreement between employers and the unions, but are nevertheless accepted by both. It must be remembered that the industry has grown up from small beginnings in the eighteenth century, when each employer paid more or less the same wage as his fellow employers in the same neighbourhood. The class of men usually referred to as skilled tradesmen, *i.e.*, fitters, turners, toolmakers, patternmakers, moulders, &c., are paid the highest basic rate, varying approximately from 45s. to 52s. per week of forty-seven hours; labourers, 29s. to 32s.; and machine men and other semi-skilled men, such as machine moulders, &c., anything from 2s. above the labourers' rate to the full rate of the skilled man, according to their skill and ability.

The cost of living bonus, as its name implies, survived after the various adjustments following the war and the subsequent trade slump in 1920. Unlike the basic wage, it is a fixed amount for all workers in the industry and is determined by agreements between the Federation and the Engineering Joint Trades Movement. For many years it consisted of 10s. per week of forty-seven hours, but in 1927 an agreement was reached whereby the timeworkers received an extra 2s. per week as some compensation due to the increased earnings of the men working under systems of payment by results. In 1935 an extra 2s. was added to all workers, time as well as those on payment by results. This was further increased in 1936 by 3s. per week to all men, 1s. per week coming into force at the end of June, September and December of that year, and again in 1937 by a further 3s. per week by two advances of 1s. 6d. on August 23rd and November 15th. These increases in the cost-of-living bonus may be summarised thus:—

Year.	Increase.	Men working on Payment by results.	Men working on Day work.
	s. d.	s. d.	s. d.
		10 0	10 0
1927	(2 0)	10 0	12 0
1935	2 0	12 0	14 0
1936	3 0	15 0	17 0
1937	3 0	18 0	20 0

So that a skilled man in receipt of a basic wage of, say, 48s. per week would receive a weekly wage of 68s. for forty-seven hours if on day rate, and a guaranteed wage of 66s., together with a piecework bonus of 12s. or more according to his ability, making, say, 78s. per week, at present.

Overtime is paid for at enhanced rates which vary according to the hours worked. For the first two hours after completing the normal day's work the rate is time and one-quarter, and for all hours worked thereafter time and one-half. In addition, if a man is sent home between midnight and 2 a.m. he will receive an allowance of plain time for the working hours from the time he was sent home until 6 a.m. If sent home after 2 a.m. he receives time and one-half for all hours unworked until 6 a.m.

Coupling up time—that is, the necessary overlapping of a day-shift man with a night-shift man to explain the position of the work when the latter takes over—is paid for at a time and one-quarter.

The usual night shift rate is time and one-sixth for all hours worked, plus, of course, overtime rates for any excess hours. Double day shift and three shift working are paid for by forty-three hours' work for forty-five hours' pay for the first shift; for the second shift thirty-seven and a-half hours' work receives forty-five hours' pay; and for the third shift thirty-seven and a-half hours' work receives forty-seven hours' pay. Each shift counts as a full week for the cost-of-living bonus.

In addition, Sundays and certain days, according to districts, are paid for at double rates. The rates of pay and conditions of employment are of such importance that the management of works should always seek the advice of the secretary of their local association of the Federation, as a very clear understanding of the complexities of the wage question is essential.

Payment by results is a system of payment of labour whereby the workman is encouraged by extra earnings to reduce the time taken on an operation. The incentive is considered by industrial psychologists as being compensation for the fatigue caused by more rapid working, either physical or mental. The system is very old, probably older than the time system, but was not looked upon with favour by workmen in the growing factory system because the conditions governing its use were not understood and employers used it as a means to work men harder with no proportionate increase in earnings, due to vicious price cutting. Since, however, its advantages have been realised, both by employers and workmen, and its application governed by fair agreements, its use has greatly extended until it not only received the blessing of the unions, but its absence is considered a sufficient cause for official complaint from the workmen to the employers. Its steady increase may be gauged by the fact that in 1914 about 70 per cent. of the engineering workers were employed on a time basis, and 30 per cent. on systems of payment by results. In 1927 the proportions were closely 50 : 50. This was the average in the industry and the percentage naturally varied according to the occupation, and to a lesser extent to the district and class of work. The skilled trades, such as fitters, turners, patternmakers, moulders, boilermakers, and the semi-skilled machine men, show a high percentage from 70 upwards, particularly the latter class, who are employed in large numbers in the motor car factories and other mass production shops. Owing to the nature of their work labourers cannot be very well employed in this manner, although some opportunities occur in jobs in unloading material, such as coal, sand, pig iron, &c., also whitewashing and painting shops, &c. In other cases labourers are attached to erectors, loam moulders, and others as helpers, and by booking their time on the piecework card participate in the bonus earned on a *pro rata* basis of basic wage for the time so booked.

Many systems of payment by results have been devised, mostly with the object of overcoming inaccurate rate fixing and fear on the part of the employer that the workman should earn too much money. The development of more accurate methods of rate fixing, including modern planning and time

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study, combined with greater confidence on the part of the workman due to this, and also to more correct methods of cost distribution, has made many of these systems obsolete. Any system of payment by results must be operated in a strictly honourable manner, and an employer who breaks faith with his men is liable to pay the penalty of having a reduced output. The conditions agreed upon between the Federation and the unions are few and simple, and fully meet the case if strictly observed. The chief provisions are as follows :—

(*a*) No piecework prices, bonus, or basis times once established may be altered except for the following reasons :—

(1) A mistake in the calculation on either side ; or

(2) The material, means, or method of production or the quantities are changed ; or

(3) A mutual arrangement has been come to between the employer and the workman in the same way as a new price is arranged.

(*b*) Piecework prices and bonus or basis times shall be such as will enable a workman of average ability to earn at least 25 per cent. over time rates, excluding cost-of-living bonus.

(*c*) In all cases day-work time rate of wages of the worker concerned shall be guaranteed irrespective of earnings.

(*d*) No debit balances shall be carried forward beyond the mutually arranged period of settlement.

It may be better, and it is better in many cases, not to correct for small errors should the price be fixed too high. The psychological effect on the men of making small downward corrections is bad, and may lead to an actual increase in time. It should be appreciated that a bonus of 25 per cent. is the minimum for a man of average ability, and a discerning works manager will see to it that his men will earn the highest bonus possible consistent with economical results.

The systems actually in use are almost exclusively confined to the following :—

Piecework on a Price Basis.—In this case a price is given for the workman's labour for the definite piece of work contracted for. The excess of the piecework price over the man's basic time wage represents the bonus paid the man. If the latter exceeds the piecework price, the man is said to be in debt by the difference, and the job has to be plussed up unless there is a surplus available from other jobs within the agreed period of settlement. If the agreed period is a week—the usual time—any bonus made in that period is used to offset debts in the same period. No debts may be carried over to the next period. If there is no bonus available or if the amount is insufficient, the man's time is made up as his weekly wage is guaranteed.

Piecework on a Time Basis.—This is similar to the above, the difference being that of giving a time for doing the job instead of a price. The method of dealing with debts applies to all systems.

Premium Bonus System.—In this the time given for the job makes provision for the workman to receive a proportion only of the wage corresponding to the time saved ; for example, one-half or one-third. This system is due to Mr. F. A. Halsey, who introduced it in the United States about 1893. It was adopted largely in this country, which caused Mr. Halsey to complain that it had been taken up a great deal more intelligently and energetically in England and Scotland than in his own country. One of its most ardent advocates was Mr. James Rowan, of Glasgow, who, however, insisted upon efficient planning and rate fixing departments. It is more than probable that this had a great deal to do with its success in this country compared with that of its origin. The editor of the *American Machinist* in 1903 commenting on a paper on the subject by Mr. John Ashford at Manchester, said : "It is notable also that this paper like many of the others which have appeared in England, emphasises the necessity of a rate-fixing or time-setting department as a starting point, whereas in this country the necessity for such a department is not felt in most shops." The popularity of the premium bonus system a generation ago was to a very large extent due to its providing a means of payment by results without the possibility of the workman being paid excessive wages brought about by want of systematic rate fixing, this being greater with piecework than with premium bonus. But as planning and rate fixing were developed and put on to scientific lines, and, further, as more accurate costing methods and distribution were introduced, piecework by its simplicity and the realisation that low costs can only be obtained by high earnings, came into favour again, and is now by far the most used of all systems of payment by results.

When considering piecework and premium bonus, it is important to bear in mind that under the agreements prices and basis times shall be such as will enable a workman of average ability to earn at least 25 per cent. over time rates. By way of example, consider a job that is time studied or estimated to take twelve hours. Whatever system is adopted, the man of average ability should receive time and one-quarter, or fifteen hours' wages if the job is done in twelve hours. Consequently, piecework prices and premium bonus times must be determined to permit this. If the basic wage is 1s. per hour, then for straight piecework the price is 15s., or, if time is given instead of a price, fifteen hours, the operator receiving 1s. for each hour by which the actual time taken is reduced below fifteen hours, in addition to his basic wage for the time taken. For premium bonus, in which the operator receives half the time saved as bonus, *i.e.*, 6d. per hour for a basic wage of 1s. per hour, the time given on the card will be eighteen hours in order that he will be paid 15s. by doing the job in twelve hours, namely, a basic wage of 12s. plus a bonus of 6d. per hour for the time saved, six hours. Similarly, for a one-third premium bonus system, the time given for the job will be twenty-one hours, and the earnings will be 12s. for the day rate plus one-third, or 4d. per hour, on the difference between twenty-one and twelve hours. As already mentioned, the cost-of-living bonus is treated as an extra and does not enter into calculations relating to payment by results.

The comparison between the three examples can be seen from Table I, where the earnings for the job, the bonus and the equivalent weekly pay are given for direct piecework and for half and one-third premium bonus, for a job estimated to take twelve hours. The diagram, Fig. 1, shows part of the information given in the table. At the estimated time of twelve hours, the earnings are the same, 15s. for all methods. By reducing the time below twelve hours, the piecework still receives 15s. for the job, but the premium bonus worker receives a steadily reducing price, as he is able to shorten the time taken. With half bonus, at nine hours he receives 13s. 6d., and with one-third bonus 13s. On the other hand, if the piecework takes fifteen hours he gets no more than 15s., the amount he would earn on day rate. But the premium bonus worker has the advantage in that, for half bonus, he would get 16s. 6d., and for one-third bonus, 17s. The former would still draw a bonus for taking up to eighteen hours, and the latter up to twenty-one hours.

As already pointed out, the chief claim made for the premium bonus system lay in the fact that by time reductions on the part of the workman excessive earnings were avoided, but as Table I and Fig. 1 show, the amount deducted from the workman for reducing his time below twelve hours, in the example taken, is really the equivalent of a bonus, should he exceed twelve hours on the job. The brake is put on to the incentive for further effort and a bonus is paid the worker for taking longer on the job than he should, thus the cost of production is increased by higher direct wages and, what is worse, by higher overheads.

The management of a works cannot afford that men should not earn a bonus, or even one smaller than that upon which the estimated cost of the product is based. If the estimating department fix the cost for the selling department on the basis of men earning 25 per cent. bonus, every man who fails to make at least this amount is adding to the loss on the article. The cost may come out right through the efforts of other men earning a greater bonus than 25 per cent., but that does not justify the employment of men not suited for their jobs, although sometimes it cannot be helped. Since in a general engineering works production times cannot always be determined with the same degree of certainty as they can be where accurate time studies are made, it is very desirable to record the actual times of all jobs. Such data are of fundamental value to the planning department and to the rate fixer. They also enable the costing department to keep the management informed of men who are in the habit of getting into debt or of having an average bonus less than 25 per cent.

To show how the cost of production is reduced by

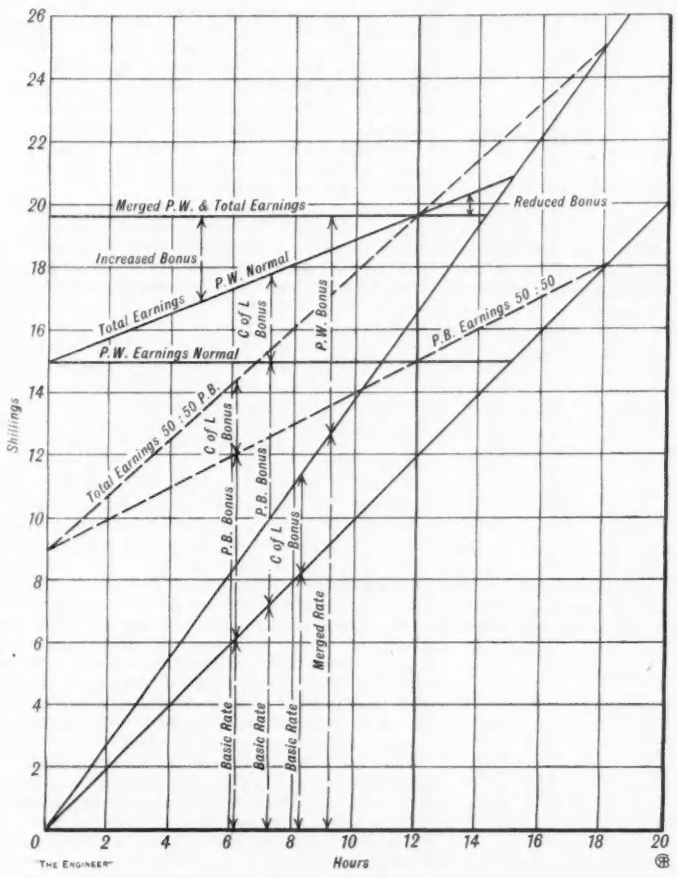


FIG. 1—DIRECT WAGES FOR A JOB ESTIMATED AT 12 HOURS

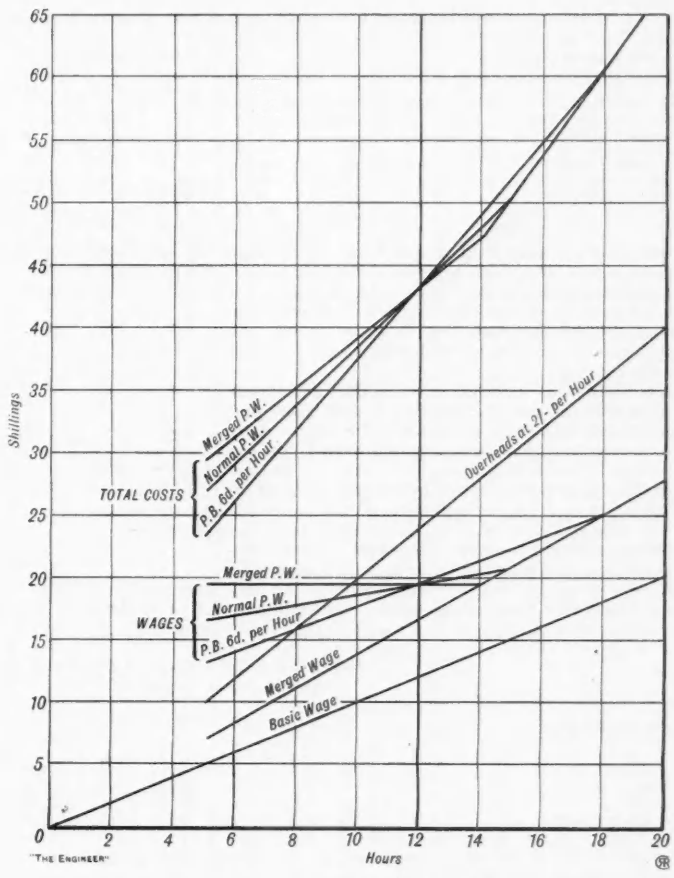


FIG. 2—COMPARISON BETWEEN WEEKLY EARNINGS AND COST OF JOB

higher earnings on the part of the operators, in Table II the overheads have been added to the wages set out in Table I. For the present purpose the factory service charges have been assumed for a certain class of machine at 2s. per hour. The direct wages and the overheads together form the factory cost of production, less the direct material used.

A comparison of the earnings per week with the cost of the job (see also Fig. 2) shows clearly the importance of encouraging high bonus and the folly of price cutting.

A point of some importance which does not appear to have received the attention it deserves is the progressive reduction of the incentive for payment by results over time work to nearly half what it was ten years ago. This has been brought about by the method of giving wage advances by increasing the cost-of-living bonus and by the reduction of the piecework bonus itself. Prior to 1927 the weekly wage for forty-seven hours, for both piece-workers and time-workers was the same, and for a skilled man was, say, 48s. plus 10s. cost-of-living bonus. To this the piece-worker had prices set to enable him to earn an extra 16s., 33⅓ per cent. on the 48s. Compared with the time-worker, his incentive was 16s. on the 58s., or 27·6 per cent. At the end of 1937 it was reduced to 10s. on 68s., or 14·7 per cent. above the time-worker. Table III gives the position :—

TABLE I.—*Direct Wages for a Job Estimated to Take Twelve Hours.*
Basic wage : 1s. per hour ; cost-of-living bonus, 18s. for forty-seven hours.
Piecework.—All Savings on Basic Wage Received by Worker.

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Basic wage	8 0	9 0	10 0	11 0	12 0	14 0	16 0	18 0
Bonus, piecework	7 0	6 0	5 0	4 0	3 0	1 0	Debt	Debt
Bonus, cost of living	3 1	3 5	3 10	4 2	4 7	5 4	6 2	6 11
Total earnings	18 1	18 5	18 10	19 2	19 7	20 4	22 2	24 11
Earnings per week	106 3	96 2	88 6	81 11	76 10	68 3	65 0	65 0
Bonus, per cent.	87·5	66·7	50·0	36·7	25·0	7·0	Debt	Debt
True bonus, per cent.	63·2	48·3	36·2	26·4	18·1	5·2	Debt	Debt

Premium Bonus—Half Savings on Basic Wage Received by Worker.

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Basic wage	8 0	9 0	10 0	11 0	12 0	14 0	16 0	18 0
Bonus, premium bonus	5 0	4 6	4 0	3 6	3 0	2 0	1 0	Nil
Bonus, cost of living	3 1	3 5	3 10	4 2	4 7	5 4	6 2	6 11
Total earnings	16 1	16 11	17 10	18 8	19 7	21 4	23 2	24 11
Earnings per week	94 5	88 4	83 9	79 10	76 10	71 5	68 1	65 0
Bonus, per cent.	62·5	50·0	40·0	31·8	25·0	14·3	6·3	Nil
True bonus, per cent.	45·1	36·2	28·9	23·1	18·1	10·3	4·5	Nil

Premium Bonus.—One-third Savings on Basic Wage Received by Worker.

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Basic wage	8 0	9 0	10 0	11 0	12 0	14 0	16 0	18 0
Bonus, premium bonus	4 4	4 0	3 8	3 4	3 0	2 4	1 8	1 0
Bonus, cost of living	3 1	3 5	3 10	4 2	4 7	5 4	6 2	6 11
Total earnings	15 5	16 5	17 6	18 6	19 7	21 8	23 10	25 11
Earnings per week	90 6	85 8	82 3	79 2	76 10	72 8	70 0	67 9
Bonus per cent.	54·2	44·4	36·7	30·3	25·0	16·7	10·4	5·5
True bonus, per cent.	39·1	32·2	26·5	22·0	18·1	12·0	7·5	4·0

TABLE II.—*Factory Cost for Job Estimated to Take Twelve Hours.*
Piecework.—Bonus, 1s. per hour.

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Total wage	18 1	18 5	18 10	19 2	19 7	20 4	22 2	24 11
Overheads, at 2s.	16 0	18 0	20 0	22 0	24 0	28 0	32 0	36 0
Total cost	34 1	36 5	38 10	41 2	43 7	48 4	54 2	60 11
Earnings, per week	106 3	96 2	88 6	81 11	76 10	68 3	65 0	65 0

Premium Bonus.—Bonus, 6s. per hour.

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Total wage	16 1	16 11	17 10	18 8	19 7	21 4	23 2	24 11
Overheads, at 2s.	16 0	18 0	20 0	22 0	24 0	28 0	32 0	36 0
Total cost	32 1	34 11	37 10	40 8	43 7	49 4	55 2	60 11
Earnings, per week	94 5	88 4	83 9	79 10	76 10	71 5	68 1	65 0

Premium Bonus.—Bonus, 4d. per hour.

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Total wage	15 5	16 5	17 6	18 6	19 7	21 8	23 10	25 11
Overheads, at 2s.	16 0	18 0	20 0	22 0	24 0	28 0	32 0	36 0
Total cost	31 5	34 5	37 6	40 6	43 7	49 8	55 10	61 11
Earnings, per week	90 6	85 8	82 3	79 2	76 10	72 8	70 0	67 9

TABLE III.—*Average Piecework Earnings as a Percentage over Day Time Rates.*

Year.	Cost-of-living bonus.		Payment by results bonus		Total earnings.		Difference.	Actual per cent.
	Time.	P. by R.			Time.	P. by R.		
	s. d.	s. d.	Per cent.	s. d.	s. d.	s. d.	s. d.	
—	10 0	10 0	33⅓	16 0	58 0	74 0	16 0	27·6
1927	12 0	10 0	33⅓	16 0	60 0	74 0	14 0	23·3
1931	12 0	10 0	25	12 0	60 0	70 0	10 0	16·7
1935	14 0	12 0	25	12 0	62 0	72 0	10 0	16·1
1936	17 0	15 0	25	12 0	65 0	75 0	10 0	15·4
1937	20 0	18 0	25	12 0	68 0	78 0	10 0	14·7

Three things have contributed to this result, the reduction of the piecework bonus from 33⅓ to 25 per cent.; the 2s. per week extra to the time-worker, as ing down the cost of production. At the present time, owing to the shortage of labour, it is not uncommon materially to increase piecework prices to ensure the workers receiving higher wages. This is particularly so with the higher classes of skilled men, such as toolmakers, patternmakers, and others, as, owing to the nature of their work, the accurate fixing of times is difficult and lieu rates and plussing up are often adopted in order to keep the men. But when work thins out, such expedients will be given up, and difficulty will then be experienced to obtain the required times to meet the falling market.

There is, of course, no reason why higher bonuses should not be paid. The agreement with the men states that the bonus shall be such as will enable a workman of average ability to earn *at least* 25 per cent. over time rates, excluding war bonus. But, apart from the amount, the question arises whether the present bonus is really an incentive to give a man reasonable compensation for a sustained effort on his part. So far as premium bonus is concerned, the answer may be stated decidedly in the negative. For piecework it can be said in its favour that the man receives a sum of money for doing a job, no matter how quickly he does it. But this is not sufficient, the reward should always be a little more than the effort, and since the effort increases at an increasing rate, the incentive should do likewise. Such a method would, however, lose the present simplicity ; but there is no reason why the present bonus paid per hour of time saved should not be increased to 1s. 6d. or even 2s.

Piecework, as generally understood, gives the whole of the wages saved by time reduction to the worker. Criticism is levelled at the premium bonus system because part of the bonus earned is retained by the employer. In this respect there is no difference, except in degree, between piecework and premium bonus as operated under the rules of the Engineering Employers' Federation, since neither system gives the whole of the saving to the workman. If, for example, the guaranteed wage under payment by results is 65s. per week—made up of 47s. basic wage and 18s. cost-of-living bonus—the bonus, expressed as an hourly rate for time saved, is 1s. 4½d., and not 1s., which is what the workman gets at present ; the 4½d. being retained by the employer. In premium bonus 6d. per hour of time saved is paid and 10½d. retained. In both cases the earnings are the same for the estimated time taken by the hypothetical workman of average ability, this being the point where the two lines cross one another.

The effect of this method of operating payment by results is shown in Table I, where the true bonus is shown by way of comparison with the bonus calculated on the basic rate, which is the official method. Instead of 25 per cent. the man of average ability has an increase to his wages of 18 per cent. Compared with the day rate worker the addition is only 14·7 per cent., so that even with 18 per cent. he starts with a handicap. After merging, if the price remains unaltered, the bonus will remain the same if the job is completed in the estimated time upon which the price was based. This is shown in Table IV, using the same example as in Table I. The comparative effect is also shown on Figs. 1 and 2.

TABLE IV.—*Piecework With Merged Wage of 65s. Per Week.*

Time taken, hours	8	9	10	11	12	14	16	18
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Price for job	19 7	19 7	19 7	19 7	19 7	19 7	Debt	Debt
Overheads at 2s.	16 0	18 0	20 0	22 0	24 0	28 0	32 0	36 0
Total cost	35 7	37 7	39 7	41 7	43 7	47 7	54 2	60 11
Earnings, per week	115 0	102 3	92 5	83 8	76 10	65 9	65 0	65 0
Day rate	11 1	12 5	13 10	15 2	16 7	19 4	22 2	24 11
Bonus	8 6	7 2	5 9	4 5	3 0	0 3	−2 7	−5 4
Bonus, per cent.	76·6	57·7	41·5	29·1	18·1	5·2	Plussed up	Plussed up
Bonus, Table I	63·2	48·3	36·2	26·4	18·1	1·3	Plussed up	Plussed up

Here the labour cost remains constant for the job, instead of decreasing slightly as it does when the price is based on the basic wage, while the bonus increases in comparison slightly. But the cost of production, the really important matter, steadily decreases as the time is shortened.

The question of merging the cost-of-living bonus with the basic wage has often been discussed ; from what has been said above there appears to be no difficulty in carrying it out by altering the 25 per cent. on the basic rate to 18 per cent., or, say, 20 per cent., on the merged rate. Generally two conditions have been considered necessary before merging could be agreed to :—

(1) Existing piecework prices or times to be used without altering their values.

(2) Increases or reductions in wages to be made without causing alterations in piecework prices or times.

It has been shown above that the change could be made without altering their values. This does not mean that the prices or times would remain unaltered, but only their values. In Table I the piecework price, based on the basic rate, is 15s.; in Table IV based on the merged rate, 19s. 7d.; but the labour costs and earnings per week on the estimated time remain unaltered. The employers would probably benefit most by simplification in cost accounting and payment of wages. Should employers wish to increase the incentive, the bonus percentage can be increased as much as is considered desirable by taking advantage of the permissive words " at least " placed before the percentage.

Opinions may differ on the desirability of not making alterations in prices or times when adjusting wages. The effect of this has been shown in Table III by considerably reducing the incentive to a reduction of production times, a policy which might with advantage to the industry be reversed. But having obtained a reasonable incentive it should be maintained, and this can only be done by allowing prices or times automatically to follow wages.

For factories working on a time basis, or recording

times, as they must do if modern methods of costing and cost control are adopted, a further incentive may be made by increasing the bonus rate above the strict piecework level. This is especially advantageous for machines having a high machine hour rate. In the example in Table IV, with a machine rate of 2s. per hour, the cost of production is reduced from 43s. 7d. to 39s. 7d. if the time is brought down from twelve hours to ten hours, a saving of 4s. or 9 per cent. in cost, excluding the material. In certain circumstances it might pay to pass the greater part of that saving on to the operator, if, for example, it avoided the purchase of a further special machine that would stand idle for the greater part of its time. But in any case time saving increases the capacity of the factory, ensuring a greater turnover without additional capital expenditure; so long as costs are controlled earnings may safely be allowed to rise.

Works management has, with few exceptions, given little attention in late years to methods of payment by results. Whether this is due to the agreements between the Engineering Employers' Federation and the unions or not, the fact remains that while there is much activity in works organisation, including planning of operations and productive methods, the wage problem is more or less taboo, and "25 per cent. over time rates, excluding cost-of-living bonus" is sacred, regardless of the fact that the real incentive, as represented by the 25 per cent., is being whittled down as shown in Table III. More attention to the words "at least" which precede the 25 per cent., and greater freedom with the bonus percentage, and especially with bonus rates, should make for a broader view in fixing bonus earnings. The relationship between bonus rates and machine hour rates, and the effects therefrom, might well deserve the attention of executives. The problem of seeking improvements in wage methods is by no means an easy one, as all who have had experience in works management know, and those who would move in this direction must proceed with considerable caution.

Control of Magnetic Quality by Surface Treatment.

By T. F. WALL, D.Sc., D.Eng.*

No. II.

(*Continued from page 669, June 17th.*)

PART II.

ARMCO IRON WIRES.

FOR the purposes of this investigation Armco iron wires were obtained of various diameters from 0·01in. up to ¼in., and the general procedure was precisely similar to that explained in Part I with reference to the tests on nickel wire.

Tests on Uncoated Armco Iron Wires.—The heat treatment for these tests was carried out at 1200 deg. Cent., and in Fig. 17 is given the curve which shows the relationship between the maximum permeability and the diameter of the wire. This curve shows that the peak value of μ_{max} is 15,000, the diameter of the wire being about 0·02in., and the curve falls rapidly as the diameter is increased or decreased from this critical value, but for relatively large diameter wires the curve is seen to become much flatter. These results show that the magnetic quality of iron wire is dependent on the diameter to a striking degree, and further reference to this phenomenon will be made later.

Hysteresis loops were obtained for samples of each diameter, the peak value of the induction density for the loop being in each case 10,000 gauss, and the hysteresis tests were taken in each case when the sample had reached a condition of maximum permeability—that is, had reached the condition to which the curve in Fig. 17 refers.

In Fig. 18 are shown the values of the coercive force H_c; in Fig. 19, the values of the remanent induction density, B_{rem}. In Fig. 20 the hysteresis loss in ergs per cubic centimetre per cycle is shown. It will be seen from these results that the coercive force and the hysteresis loss reach minimum values for wires of diameter for which the value of μ_{max} is a maximum.

In Fig. 21 are given the results of tests for the specific electric resistance of uncoated Armco iron wires in the "as received" condition. The pronounced increase of specific resistance for wires of small diameter is of considerable interest as an indication that the physical properties of the surface layer of the wire are different from those of the core of the wire and such difference would, of course, become increasingly obvious as the diameter decreases. The same general effect is seen from the corresponding tests data for nickel wire as shown in Fig. 8 (*ante*).

In Fig. 22 are shown the results of measurements of the values of Young's modulus, and these results may be compared with the corresponding results for nickel wire given in Fig. 16 (*ante*). It will be noticed that in the case of Armco iron the value of the modulus does not appreciably decrease until the diameter of the wire becomes less than about $^1/_{64}$in.

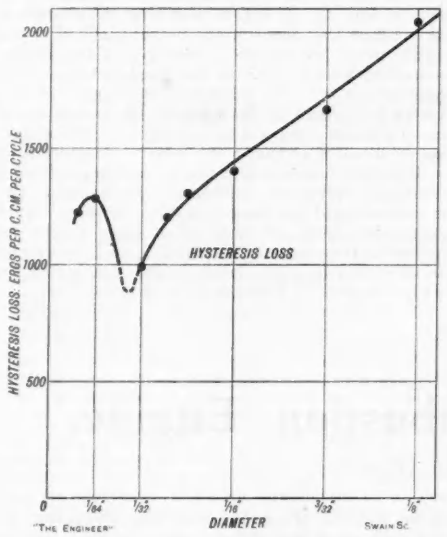


FIG. 20

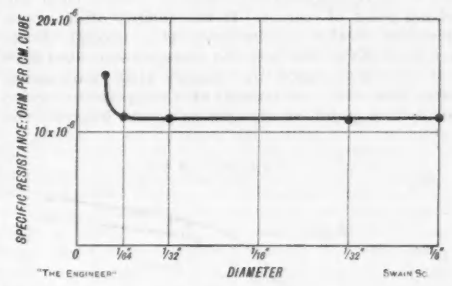


FIG. 21

commenced in accordance with exactly the same procedure as already discussed in Part I with reference to copper-coated nickel wires. So far, results have been obtained for wire of $\frac{1}{16}$in. diameter, and these results are shown in Fig. 23. The temperature of heat treatment was in this case 1320 deg. Cent., it having been found that for temperatures below the melting point of manganese, viz., 1260 deg. Cent., the effect of the coating on the magnetic quality is relatively insignificant. During the heat treatment at 1320 deg. Cent. the manganese becomes fluid, and the remarkable improvement of the magnetic qualities is to be seen from the results given in Fig. 23. The following table gives the values of the leading magnetic characteristic quantities for the manganese-coated wire and the uncoated wire :—

	Uncoated wire.	Manganese-coated wire.
Maximum permeability	6,200	11,500
Coercive force	0·48	0·23
Remanent induction density	6,100	4,400

The investigation is being continued to embrace manganese-coated wires of a wide range of diameters, and, judging from the corresponding results obtained for copper-coated nickel wires, the maximum permeability of wire of smaller diameter than $\frac{1}{16}$in. should be very much higher than the value 11,500 given in the foregoing table.

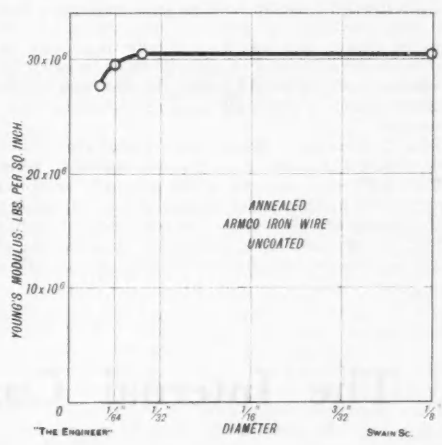
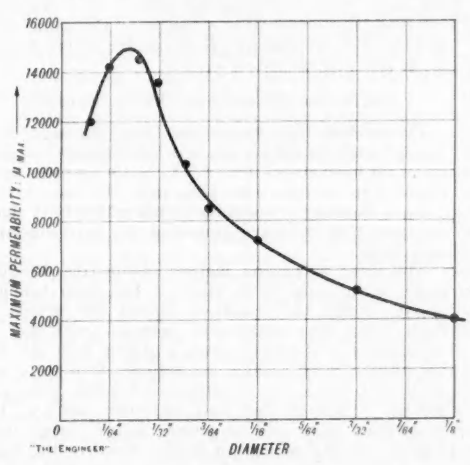
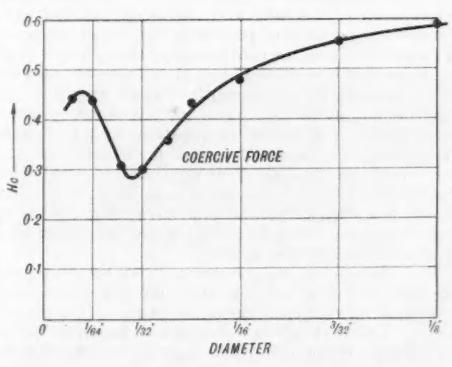


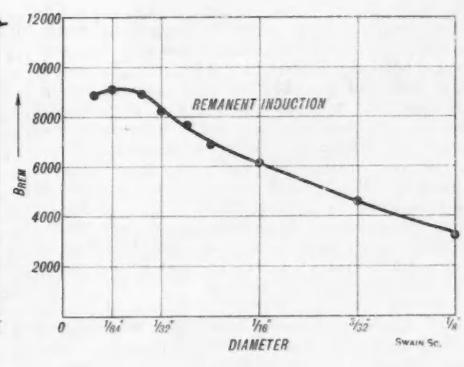
FIG. 22

The behaviour of a manganese coating in improving the magnetic quality is particularly surprising when it is recalled that the non-magnetic quality of Hadfield's manganese steel is due to the manganese content of from 10 to 12 per cent., the maximum permeability of this steel being only about 1·2.

In the table of atomic numbers it is seen that the







FIGS. 17, 18 AND 19

Tests on Manganese-coated Armco Wire.—In connection with these tests it is to be observed that the element manganese is non-magnetic in so far as is at present known. For the purpose of investigating the effect of heat treatment at a suitable temperature of manganese-coated wires a series of tests has been

metals under consideration are placed as follows :—

Metal.	Manganese.	Iron.	Cobalt.	Nickel.	Copper.
Atomic number	25	26	27	28	29

In the results given in Part I the improvement of the magnetic qualities of copper-coated nickel wire have been shown for the case in which the heat treatment was carried out at from 1100 deg. to 1150 deg. Cent.; that is, at a temperature which is greater than the melting point of copper. It was mainly after a consideration of this circumstance that special efforts were made to obtain tests on manganese-coated wire as it was anticipated by analogy that manganese-coated iron wire heat treated at a temperature above the melting point of manganese would improve the

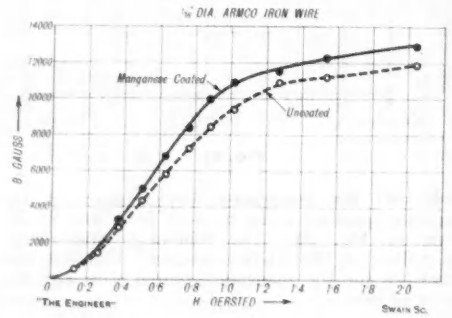


FIG. 23

magnetic qualities of iron in a similar way that copper-coated nickel wire was improved when heat treated above the melting point of copper.

A further branch of this investigation includes the examination of the effect of a copper coating on a manganese layer and heat treated at a temperature which is greater than the melting point of copper, but less than the melting point of manganese. It is expected that in this way some further light may be thrown on the behaviour of manganese as an essential constituent of the well-known Heusler and other magnetic alloys in which all the constituents are non-magnetic.

Some Conclusions.—Many of the results which have been obtained in these investigations appear to be in conflict with some aspects of the generally accepted theory of the mechanism of magnetisation. A number of the results are obviously of direct practical significance, one of these being that tests on a sample of magnetic material can have little significance unless the cross-sectional area and the outline of the section are known. Hitherto no practical importance appears to have been attached to the specification of the dimensions of the specimen, particularly as regards the ratio of the perimeter of a section to the area of that section.

The results in general can be explained if it be accepted that there is a surface layer of the normal uncoated specimen which is magnetically harder than the core of the specimen, and if it be further assumed that this surface layer is thicker for wires of small diameter than for wires of large diameter.

It is also an implication of the test results that when a wire is placed in the magnetising field of a solenoid the surface layer of the wire is first magnetised and that this layer magnetises the next layer and so on, the magnetism penetrating by a kind of chain effect from the surface. This assumption would lead to the conclusion that the induction density developed in a magnetised wire when it is placed in a steady magnetising field is of gradually decreasing magnitude as the axis of the wire is approached. The usual magnetic test for the induction density will thus give the average density over the whole cross section, but does not give any direct information as to the value of the maximum flux density in the section. This suggested process of magnetisation appears to be implicit in many of the test results, and the writer hopes to be able to return to a further consideration of this question on another occasion.

The improvement of the magnetic quality of the manganese-coated Armco wire has a further directly practical significance from several points of view. The increased permeability denotes a corresponding reduction of the requisite magnetising ampere turns, and this will apply particularly to the design of transformers and the magnetic circuits of A.C. and D.C. machinery. By decreasing the number of ampere turns not only is the requisite weight of copper reduced, but the copper loss is also reduced and consequently the efficiency of the machine or other apparatus correspondingly increased.

There is, however, another and quite different aspect of the comparison of the magnetisation curves shown in Fig. 23. It will be seen that the characteristic bend of the curve in the neighbourhood of the origin is much less marked in the case of the manganese-coated sample than in the uncoated wire. By straightening out the magnetisation curve in this way the harmonics in the magnetising current wave-form of a transformer will be correspondingly reduced. This problem of reducing the relative magnitude of the distorting harmonics in the current wave-form is one of great practical importance, particularly since the national grid has come into full operation. Much thought has been given as to suitable means for eliminating this source of disturbance, and the subject was discussed in some detail at the meeting of the V.D.I. Congress at Königsberg in August, 1937.

The Internal Combustion Engine.*

By H. R. RICARDO.

Detonation.

ACCORDING to the simple rules, a mixture of air and petrol vapour, oxygen and nitrogen, hydrogen and carbon, is compressed in the cylinder. At the appointed time a light is set to this highly inflammable mixture. There follows an instant of violent scramble and confusion. When the clamour and the fighting are lulled, it is found that the hydrogen has mated with some of the oxygen to form steam, the carbon has embraced the rest to form carbon dioxide, while the nitrogen remains unloved, disdainful, and alone.

With this simple and entirely orthodox evolution, we once were perfectly content, but inquisitive minds began to inquire what is really happening during the scrimmage itself, and more especially at, and even just before, the start of the scrimmage, and to suspect that just possibly every oxygen atom did not at once find its right partner, and, darkest suspicion of all, that the nitrogen's behaviour was not quite so platonic as she would have us believe. Alas, the more deeply we probe, the more scandals we unearth. We find that the fickle oxygen has formed all sorts of unholy alliances before finally settling down to a steady partnership, while even the aloof, and apparently chaste nitrogen has had at least one affair under cover of the general confusion, and a very disgraceful one at that.

In that one thousandth part of a second or less, all kinds of unstable alliances have been formed and dissolved again, but some of them have endured long enough to exert a powerful and malign influence, while, in some cases, their very instability has itself been a source of danger.

To-day it is realised that it is not the final partnerships, but the fleeting, excitable, and temporary liaisons that are the cause of all our worry, and the chief inciters of detonation ; they, in fact, are the hot heads who start the rough house.

Many of these have already been identified, some few have been scotched, but many more are probably still undetected. For want of a better name, these illicit alliances are called products of partial combustion, because for the most part they exist and have their being only during the actual process of combustion, and disappear when combustion is complete ; but not quite all. Some, though probably only a few, are formed actually a little before the passage of the spark during the heat and confusion of compression. Thus they are transient only, and cease to exist when combustion is complete and the oxygen atoms have found their permanent partners, but, when the wave of flame breaks on the cold shores of the cylinder walls the process of combustion is suddenly arrested and the merry-making halted abruptly. Here, then, on the extreme outer fringes, some of the illicit couples, these products of partial combustion, may be caught embracing, for the sudden chill of contact with the cold walls has frozen them rigid before they have had a chance to disengage themselves. When we search the wide ocean nothing do we find ; it is by examining the foam left behind on the shore that their existence can be detected.

It is certain of the transient products of partial combustion, probably the unstable peroxides, that are the active instruments in the cause of detonation, and to-day we do all in our power to be rid of them ; an attempt is made to discourage their formation by introducing the hydrocarbon in the form of the more stable ring molecules, rather than the loose chains of the paraffin series, or, again, an oxygen atom may be insinuated in advance into the molecule to act as a chaperone, as when using alcohol or acetone. In such matters, the *rôle* of the chemist and the designer is that of a social reformer in an uproarious and improper night club. The chemist can issue the invitations and so, to some extent at least, can choose the company. The designer can ensure that there are no secluded corners in his design of the room. In the last extreme, we descend to the *rôle* of the rat-catcher, and seek to poison these undesirables with dopes, such as lead tetraethide, better known perhaps as "ethyl fluid." By such means, success has been attained in reducing enormously the tendency of fuels to detonate, and thus in removing the greatest barrier to power output.

While certain of the transient products are the active instruments in detonation, some of those cast out on the fringes of the flame are the active cause of cylinder wear, for they burrow into and try to hide their shame in the walls of the cylinder barrel, like white ants in a packing case, and the colder the barrel, the more actively, and the deeper do they burrow. In this direction nitrogen's liaison is now believed to be the worst offender of all, and the most eager to hide its shame.

Combustion in the Diesel Engine.

I have said a good deal about the combustion process in the petrol engine because it is, at the moment, a subject of renewed and very intensive study. Much of what I have said applies also to the Diesel engine, but with two important differences. First, the bogey of detonation is absent, and, secondly, combustion is initiated, not by the passage of a spark but by the ignition of a surface layer of vapour surrounding countless thousands of minute droplets of liquid fuel.

* * * *

In order to enable the fuel to reach the outskirts of the combustion chamber, and so make the acquaintance of the suburban oxygen, a high degree of penetration was essential. In order to present the largest possible surface for combustion, it was essential that the fuel should be pulverised as finely as possible. Unfortunately, pulverisation and penetration are mutually contradictory. The blast air achieved both ends, but by no amount of jiggery-pokery can an injector nozzle be made to combine the pulverisation of a scent spray with the penetration and range of a fire hose.

Other means had therefore to be found to bring the fuel and air together. All kinds of ingenuity were invoked in attempts to find a compromise between these two irreconcilables, but with only partial success. At long last, someone suggested what seems the obvious—if the fuel cannot be delivered to the suburbs, why not let the suburbanites come to town and fetch it ? In other words, it if is difficult to set the fuel to find the air, then why not set the air to find the fuel ? It is far easier to set air in motion and, if necessary, into very rapid motion, than to search it out with jets of finely pulverised liquid fuel. Moreover, if the motion of the air is sufficiently rapid, it will help in the pulverisation.

To-day, all high-speed Diesel engines operate, to a greater or less degree, on the principle of setting the air within the combustion chamber to find the fuel. In some cases the air is given a rotational movement as it enters the cylinder by means of baffles or guide vanes on the inlet valve ; in others, it is compressed through a tangential passage into a separate spherical chamber, wherein it sets up a violent rotational swirl ; in others yet again, the sudden displacement of the air trapped between the piston and cylinder head is used to produce something in the nature of a vortex ring, but in all cases the principle is the same, namely, that of setting the air to search out and find the fuel.

In general practice, the single jet and intense air swirl, on the whole, serve best in small and very high-speed engines, and the multiple jet and more moderate swirl in the larger sizes. The former entails greater heat losses and therefore a slightly lower thermal efficiency, but it is possible thereby to burn considerably more fuel in a cylinder of the same size, and therefore to obtain a greater power output from a given size and weight of engine.

The Light High-speed Diesel Engine.

The modern light high-speed Diesel engine is first cousin to the petrol engine, which it resembles closely in all its mechanical details. It bears no more relationship to its namesake than does the hare to the buffalo, the only common factor being that both share the same diet and have somewhat the same digestive processes.

The most surprising feature about this development is the ease with which it has been brought about. Once the tradition, almost the article of faith, that the combustion process could not be speeded up, was broken down, and only audacity and impudence were needed to achieve this step, the problem became one of mechanical design pure and simple. Compactness and extreme rigidity, the underlying principles of petrol engine design were found to apply with even greater force to the high-speed Diesel engine, and once these principles were adopted, the new engine was found to be just as flexible, lively, and versatile as the petrol engine. In deference to the higher pressures involved, still greater rigidity was given to the crankshaft, and to the engine structure generally, but, apart from this, the design follows closely that of the petrol engine.

The imposition in this country of a heavy tax on Diesel fuel used for road vehicles, has handicapped

* Excerpts from a paper entitled "The Progress of the Internal Combustion Engine During the Last Twenty Years," read at The International Engineering Congress, Glasgow, June 21st, 1938.

tragically the development of the Diesel engine in the smaller classes of commercial vehicle, but on the Continent it has developed apace. To-day, for example, the Citröen Company in Paris are turning out very small mass-produced Diesel engines for taxi-cabs and light delivery vans, engines of only 1·7 litre capacity, which develop 46 H.P. at no less a speed than 4000 r.p.m.

So far, the high-speed Diesel engine for road vehicle work has been developed only in the four-cycle edition and has followed closely on the lines of contemporary petrol engine practice. There would appear, however, to be very strong arguments in favour of the two-cycle type, more especially for the smaller class, on the grounds that by doubling the proportion of power strokes better use can be made of the materials of construction, and, since the same equality of turning moment can be obtained with half the number of cylinders, only half the costly fuel injection equipment will be required.

AERO-ENGINES.

The aero-engine represents the summit of all that science and practical mechanics, acting in combination, have yet achieved. Also it is in a class apart, for it is the only prime mover of really large power and extremely light weight. The average military aero-engine of to-day develops round about 1000 H.P. and weighs little more than 1000 lb., an achievement made possible only by exquisite design and workmanship, and by utilising to the full all that the most up-to-date science can provide. Its thermal efficiency is the highest of that of any prime mover operating on a similar heat cycle, and, moreover, its mechanical reliability and durability are extraordinarily high.

People are apt to look upon the aero-engine as a brilliant piece of design, but as a delicate mechanism, forever requiring skilled attention, and unable to endure for any length of time, yet the modern aero-engine, despite its high output and high average working load factor, is normally capable of covering 100,000 miles without overhaul, while many engines have a total of over 500,000 miles to their credit.

The last twenty years have seen an enormous advance in the performance of the aero-engine, an advance which in that period has considerably more than doubled the power output from the same size or weight of engine, while the specific fuel consumption has been reduced to only about 60 per cent. Most of this improvement has been accomplished during the last five years, and is to be attributed mainly to improvements in the fuel, due to our increased knowledge, both of the requirements and how to attain them.

To-day, as I have said before, we classify fuels by their tendency to detonate, and this is expressed in terms of their octane number. The best quality fuels supplied at the roadside pump have an octane number ranging from 75 to 80. Aviation fuel to-day has an octane number of 87, and great efforts are being made to produce large supplies of 100 octane petrol. As between 80 and 87 octane petrol, the possible power output of a supercharged aero-engine is increased by about 15 per cent., as between 87 and 100 octane it is still further increased by about 30 per cent., thanks to the higher ratio of compression, and still more to the greater supercharge permissible within the limits set by detonation.

A recent development which bids fair to have very far-reaching effects is that of the use of a single-sleeve valve with combined reciprocating and rotary motion. This has some very important advantages, in that the valve mechanism no longer imposes a mechanical limit to the speed of rotation, the absence of the hot exhaust valve allows a higher compression or a higher supercharge to be used within the limits set by detonation, while the motion of the sleeve tends to transfer heat from the hot zones to other parts of the cylinder barrel. The sleeve valve aero-engine has been in the experimental stage for a good many years, but it is now coming into routine production—its possibilities are still by no means fully explored, but some quite remarkable performance figures have been obtained experimentally, considerably in advance of anything obtained with poppet valve engines on the same fuel.

DIESEL ENGINES FOR AIRCRAFT.

The question arises constantly why the Diesel engine is not used for aircraft. It is argued, and rightly, that the Diesel engine is more economical of fuel, and therefore will give a longer range of flight; that it uses a fuel which is cheaper, and, above all, which frees us from the risk of fire, either in the air, or in the event of a crash; and that its reliability and durability have already been proved up to the hilt by the experience of many thousands of such engines in road service. All these are very cogent arguments and would appear to be entirely convincing, but when they are analysed quantitatively, the results are apt to be disappointing. In the first place, the modern aero-engine, using a high octane fuel, can show a specific fuel consumption so nearly equal to that of the Diesel engine, that it is only on extremely long non-stop flights that the latter can show to any real advantage, flights far longer than either ordinary military needs call for or travellers are prepared to endure.

Owing to its very high maximum pressures, the Diesel engine, in its accepted four-cycle form, is necessarily very considerably heavier than (probably nearly double) the weight of a modern 100 octane petrol engine of the same output, and this single factor overides all the other arguments except perhaps the fire risk.

To the military authorities the avoidance of fire risk makes no appeal at all. The military pilot will merely say that if, owing to a heavier machine, he is in danger of being out-manœuvred and shot down by the enemy, it matters little to him whether his funeral takes the form of burial or cremation. Moreover, engine weight alone is by no means the only factor, for a heavier engine involves a heavier structure to carry it, and a greater wing area to support it, and is therefore reflected throughout the whole machine.

Five years ago, and before the great advance in power and economy due to higher octane fuel, the Diesel engine was running the petrol engine very close in the race for the air, but now the petrol engine has forged ahead, and again established a substantial lead.

In the above considerations, I have had always in mind the high compression four-cycle heavy oil engine, but there are possibilities in other directions, possibilities which are being closely watched, and on which much exploratory work is being carried out. Chief of these are the low compression but highly supercharged Diesel engines, a form which bids fair to provide as good a power-weight ratio as the modern petrol engine, since it will give at least the same mean effective pressure with little or no higher maximum pressure, but, ironical as it may seem, in this form the Diesel will have a greater fuel consumption than the petrol engine. It has the advantage, however, that it involves but little departure from well-tried practice.

Another possibility, also under careful consideration, is the single-piston two-cycle engine. Present indications are that with this type it may be found possible to produce an engine even lighter per horse-power than the petrol engine, combined with a somewhat lower specific consumption. This, then, would appear to be the goal at which to aim, but many mechanical difficulties will have to be overcome ere it is reached.

The Germans have developed a double piston two-cycle engine which has achieved considerable success, but the construction is necessarily heavy, in that it involves two crankshafts, two crank cases, and a long train of connecting gearing for only a single line of cylinders. It is perhaps the easiest, but it is hardly likely to prove the final solution of the two-cycle problem.

STEAM *versus* INTERNAL COMBUSTION.

Personally, I feel no doubt but that, until the advent of the internal combustion turbine—not, I think, very far distant—the future of the internal combustion engine lies with the small high-speed version, growing ever smaller and running ever faster.

I regret it, as I regret much else that is passing. Gone for ever is the impressive magnificence of the large and stately steam engine, with all its romance and unhurried dignity, its gleaming muscles, and its rhythmic breathing. In its place, we have a fussy little busybody which stirs no thrill in any breast, but, none the less, does all we ask of it, and does it economically and conscientiously. Of such an engine we require that it shall be entirely self-supporting and reliable during its working spells, and that its capital cost shall be so low that we shall not hesitate to scrap it as soon as it becomes obsolete. We are accustomed to tell ourselves that we live in an age of rapid progress. If we really believe this, then what is the use of building engines to last more than, say, ten or fifteen years? Our forefathers were wont to boas that they built machinery to last a century, and thi they accounted a virtue. In so doing, they erected impressive monuments to themselves, but left most embarrassing heirlooms for their descendants.

Low first cost, light weight, and ease of transport are the needs of the present day. Let us be content to supply these and to leave our successors a free hand to make use of the better knowledge and altered conditions which will be their portion.

Empire Exhibition, Glasgow.

No. VIII.

(*Continued from page 674, June 17th.*)

WE continue in the following article our description of the engineering exhibits at the Empire Exhibition, Bellahoustion Park, Glasgow.

RITCHIE-ATLAS ENGINEERING COMPANY, LTD.

Various forms of mechanical handling plant are displayed on the stand of the Ritchie-Atlas Engineering Company, Ltd., of Atlas Works, Temple, Glasgow, W.3. Illustrated in the accompanying engraving, Fig. 52, is a portable belt conveyor for handling coal, coke, sand, gravel, and all granular materials. The conveyor consists of a steel structure, braced and cross-braced to prevent twisting, on which at frequent intervals are fitted troughing units made up of cast iron rollers mounted on hollow spindles carried in cast iron brackets. Roller lubrication is effected by the Stauffers system, the lubricant being fed to the centre of the bearing and exuding at the sides, so that no dirt or grit is carried to the running faces. End pulleys of large diameter are mounted on mild steel spindles, supported in ball bearing self-aligning plummer blocks of dustproof construction. Tension boxes are arranged at each end to adjust the tension of the belt and maintain alignment. Of india-rubber and canvas, the belt is sufficiently flexible to trough on the carrying side; suitable supports are arranged for the return belt. Guards are placed on each side to prevent material falling in transit and a plough is fitted at the bottom end to remove material from the return belt. At the receiving end a sheet metal hopper is arranged to direct the material on to the centre of the belt and to prevent side spillage taking place.

The machine can be driven by an electric motor or by a petrol engine, as illustrated, mounted on a superstructure over the feeding end. Power from the driving unit is transmitted to the head shaft by a series of Renolds chain reductions, mounted on sprockets

FIG. 52—PORTABLE BELT CONVEYOR—RITCHIE-ATLAS

machine cut from solid blanks. The sprockets are mounted on mild steel spindles carried in self-aligning plummer blocks.

The conveyor illustrated is fitted with an elevating mast so that the elevation at the point of discharge can be varied between a minimum of 7ft. and a maximum angle of 30 deg. Control of this operation is by means of a hand-operated self-locking worm gear winch fitted with ball bearings and ball thrust washers. Swivelling axles for the wheels enable the machine to be moved in a direction at right angles to the direction of the belt ; also, when the axles are locked in an

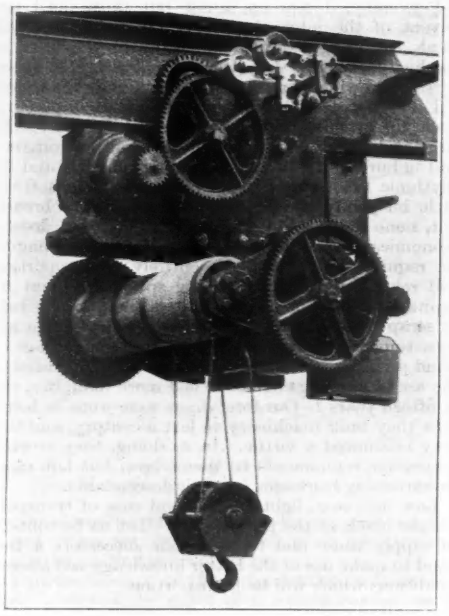


FIG. 53—ELECTRIC HOIST BLOCK—RITCHIE-ATLAS

intermediate position, the conveyor can be moved in a circular path with the hopper as centre. The wheels, fitted with Dunlop tyres, are mounted on Timken bearings. Conveyors of this type are made in lengths varying from 21ft. to 39ft., with belt widths of 16in., 20in., and 24in. When fed at a uniform rate of loading the 16in. belt is stated to carry 40 tons of coal per hour, the 20in. belt 60 tons, and the 24in. belt 80 tons.

Another exhibit shown on the stand is a series of electric hoist blocks, typical of the range manufactured by the firm, such as is illustrated in Fig. 53. The hoist framework is constructed of mild steel plates and sections, which are made from templates and designed for strength and low weight. So as to

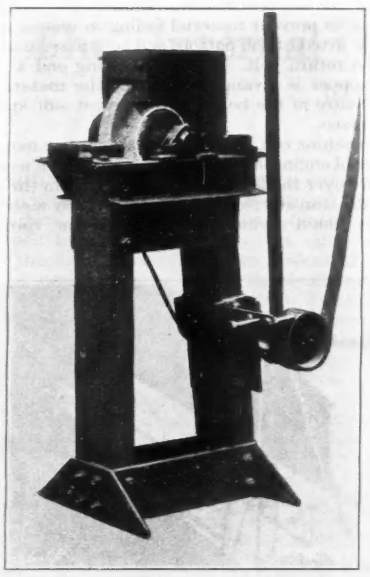


FIG. 54—GRINDING MACHINE—RITCHIE-ATLAS

take the rope without overlapping, the barrel is turned all over and grooved right and left-hand. Made of high-tensile flexible plough steel, the rope is rigged through the bottom block in four parts, passing over an equalising pulley, so that each part is equally loaded and the hook rises vertically. The bottom block consists of two grooved pulleys, gunmetal bushed, supported on a steel crosshead in which the forged load hook is supported in roller bearings. Power from the motor is transmitted to the barrel through spur gear reduction trains. The motor, which is operated from a reversing contactor controller, with a spring-operated return to the "off" position, is claimed to be of ample power for its duty. A series limit switch is fitted to prevent overwinding, and coupled directly to the motor is an electro-mechanical brake which comes into action as soon as the current supply is interrupted. Current from the mains can be picked up from flexible cables or bare copper wires, supported by line ears and insulated bolts by means of shoes or other current collectors.

This type of hoist block is made in various forms, such as a travelling pattern built into a steel trolley, the wheels of which are driven by a separate electric motor through gearing, as shown in Fig. 53. Alternatively, the trolley can be pushed manually, in which case it is mounted on flanged wheels which are suitable for running on rolled steel joists. Hoists are made by the firm suitable for loads ranging from ½ to 5 tons.

A general workshop grinding machine manufactured by the firm, which is robustly constructed and suitable for heavy use, is also shown on the stand. The machine is illustrated in Fig. 54; it is driven by belt, but an electric motor drive can be readily arranged. From the countershaft the drive is taken to the grinding spindle by V rope and V section stepped cone pulleys, which provide three wheel speeds. The countershaft is carried in totally enclosed ball bearing plummer blocks, and when a loose pulley is fitted, it also is mounted on ball bearings. For an electric drive a push-button control switch is provided, or a pedal switch furnished—in the last-named case the switch ensures that the machine stops automatically when the machine is not in use. The frame of the machine is constructed of standard sections and plates, and is claimed to be practically indestructible. Sheet metal guards are arranged over the stone and belt drive. The spindle is mounted in totally enclosed ball bearings, which are claimed to be proof against the entry of dirt and grit.

SIR WILLIAM ARROL AND CO., LTD.

On the stand of Sir William Arrol and Co., Ltd., of Dalmarnock Ironworks, Bridgeton, Glasgow, there is exhibited a series of models and machines

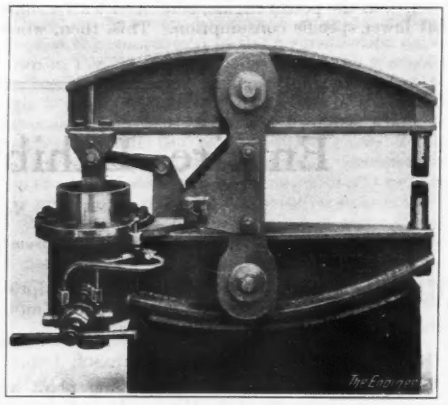


FIG. 55—HINGED RIVETING MACHINE—ARROL

illustrating the wide range of civil and structural engineering work undertaken by the firm and its application in harbours, shipyards, and industrial plants in all parts of the world.

In Fig. 55 we illustrate one of two types of riveting machines shown on the stand, which were first made for works use, and are now being supplied for clients' use. The machine shown is a hinged or scissors pattern hydraulic riveter, which is built up of strong-section welded plate, and is, the makers claim, lighter in weight, stronger, and more handy

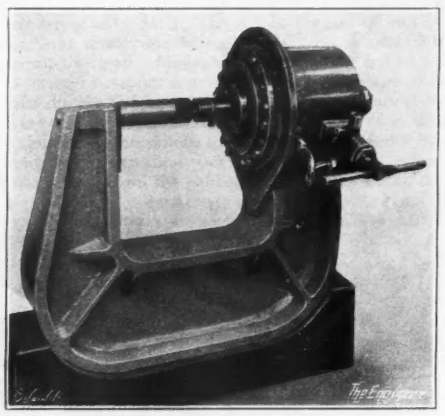


FIG. 56—BOW RIVETING MACHINE—ARROL

for manipulation than a machine of equal output made in cast steel. It has a designed load on the rivet of 28 tons with a water pressure of 900 lb. per square inch, the depth of gap being 24in. and the daylight 13½in. The bow pattern riveter which we illustrate in Fig. 56, has a generally similar construction. The load on the rivet for the machine exhibited is 50 tons with a water pressure of 900 lb. per square inch, a depth of gap of 18in., and a daylight of 18in. There is no standard gap for these machines, as size of gap varies with the customer's requirements. Riveters with gaps up to 7ft. have been constructed and are giving excellent service in British shipyards.

In the engraving, Fig. 57, there is illustrated the R.L. gas cutting machine, which is manufactured by Sir William Arrol and Co., Ltd., for the British Gas and Torch Company, Ltd., of 10, Victoria Street, London, S.W.1, and 62, Robertson Street, Glasgow, C.2. This profiling machine has a cutting area of 60in. by 39in., with cutting thicknesses of from $\frac{3}{16}$in. up to 6in. or 9in., if required; special machines are supplied for cutting lengths up to 30ft.

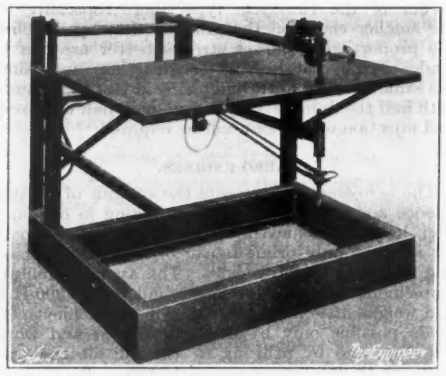


FIG. 57—GAS CUTTING MACHINE—ARROL

The base frame is a heavy channel steel welded base to which is attached the braced vertical arm which carries the double hinged arms. The longer of these arms is forked, the upper half carrying a motor-driven tracing head while the lower half supports the cutting burner. The tracing head moves on a template or drawing placed on the table, which is of welded steel in order to prevent distortion, and is covered with a renewable surface of Masonite. The table can be swung back to allow heavy work to be placed into position by a crane. The tracing head floats vertically with constant downward pressure on the tracing wheel, and any irregularity in the level of the table does not affect the operation of the machine or the speed and load in the motor. The tracing wheel is driven through worm reduction gear, in which provision is made for taking up the play. The cutting burner is of the makers' design and manufacture, and it is simple in construction and easily dismantled. It can be raised and lowered by means of a rack. The main cutting oxygen valve is controlled by a Bowden wire, the operating lever being fixed to the edge of the table near the motor switch. Two cocks are fitted to the burner itself for adjusting the gas and the heating oxygen.

Particular interest attaches to the R.L. electro-mechanical speed regulator for the motor, designed to give a one-to-five speed regulation which can

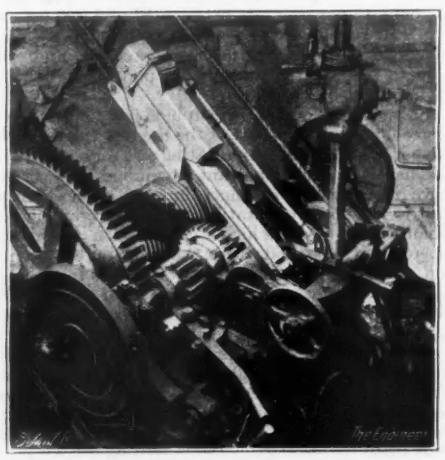


FIG 58—SAFE LOAD INDICATOR—ARROL

be varied while the machine is in operation and is independent of any variation of the voltage supply or the load on the motor. The principle employed is as follows.

A governor is fitted to the motor shaft, and a lever operated from the governor spindle compresses two spring struts. To these struts are fitted insulated tungsten contacts, which short circuit a resistance in series with the motor supply. When the speed falls below the normal figure, the resistance is cut out, and the speed rises immediately. Any tendency of the speed to rise is checked as the governor immediately compresses the springs, and the resistance is again inserted in circuit. The contacts are continually vibrating, and the speed is kept constant within fine limits, and is unaffected by load or main voltage variations. The speed is varied by means of a leaf spring fixed to the governor-operated lever, which weakens the effective push of the struts on low speeds.

A noteworthy exhibit in the crane section is a Wylie safe load indicator which is manufactured by the company. The indicator automatically warns the crane driver by a red light as soon as the load lifted reaches the maximum capacity of the crane. At 10 per cent. overload an alarm bell rings in the driver's cabin. An actual crane indicator is exhibited, and in Fig. 58 we show an indicator installed on a crane. The accompanying drawing, Fig. 59, serves to explain the principle upon which the type A.I. indicator works.

The indicator is hinged on the axle pin A and houses the usual mast pulley B, also a deflector pulley D in its lower part, which is hinged to the upper part at C and strutted from it by E F. E F is a Wylie bending strut which operates the warning signal when subjected to one definite force and the danger signal when subjected to a greater force. The downward lead R of the lifting rope is deflected by D, which it presses outwardly, thus opposing the tendency of the indicator to swing downwardly as a whole about A under the pressure on B of the outward lead R R.

If the indicator were free it would swing about A

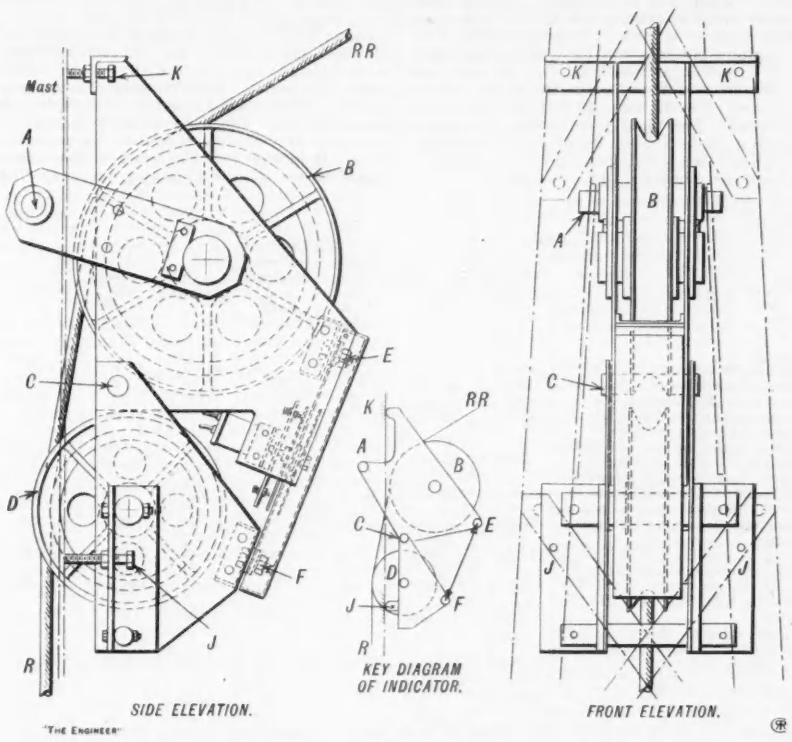


FIG. 59—ARRANGEMENT OF SAFE LOAD INDICATOR—ARROL

up and down with R R, but a stop K is set to contact with the mast when the jib is at the maximum radius at which maximum load may be lifted.

When the jib is raised from this position, over the maximum load range, the top part of the indicator acts simply as a fixed bracket resting on K, and the pressure on D and hence the thrust on E F, remain constant. As the jib is lowered from maximum load radius J comes into action as a stop, and the pressure on it increases as R R inclines downwards. The pressure on J causes a thrust on E F additional to that caused by D, and since the total thrust which causes a signal is a fixed amount, the load on the crane must diminish as the jib is lowered. The rate at which the load diminishes is greater the greater the distance of J from C, and J is therefore definitely fixed to suit the approved loading schedule. The friction in the pulleys is used to assist the signals to be given when the crane is working towards danger when lifting or derricking out, and to stop them when the motion is reversed.

Any description of this stand would be incomplete without some mention of the many fine models, shown, most of them representing works already fully described and illustrated in the pages of THE ENGINEER. They include a scale model of $\frac{3}{16}$in. to 1ft. of the 250-ton hammerhead fitting-out crane at the Walker Yard of Vickers-Armstrongs, Ltd., Newcastle-on-Tyne. A similar crane is now under construction for Vickers-Armstrongs, Ltd., Barrow-in-Furness.

In addition to the main trolley, the crane has a 20-ton portal crane travelling the full length of the jib. The crane is shown handling a scale model of a 16in. naval gun.

There is also an electrically operated working model to scale of $\frac{3}{16}$in. to 1ft. of a large ore bridge recently constructed at Ebbw Vale for Richard Thomas and Co., Ltd. It is fitted with a Priestman grab of 140 to 175 cubic feet capacity with a total traversing distance of 208ft. Two similar ore transporters, but of larger capacity, are now under construction by the company for the United Steel companies, Ltd.

The bridge models include one of the road and rail bascule bridge and approach span over the river Trent at Keadby, the Scherzer span of which bridge is the heaviest of its type in this country; also a model of a small trunnion type of Arrol-Werkspoor bascule bridge which the company has developed. A model of the box-type flap-gate recently built by the firm for the Elderslie Graving Dock on the Clyde is shown, along with models of a 5-ton box-charging machine for charging open-hearth steel furnaces, and a 300-ton overhead crane and building, the crane being equipped with a turning gear arranged for forging. This building and crane were constructed for English Steel Corporation, Ltd., Sheffield. The crane is, in fact, in use for handling the larger ingots like that illustrated by the model of the 230-ton ingot and furnace on the English Steel Corporation's stand. The sides of the building are partly sheeted with asbestos cement sheets, and the roof is covered partly with sheeting and partly by ten stretches of glazing arranged to provide ample ventilation.

In conclusion we may mention that the steel framework of the Palace of Engineering itself, the largest building in the Exhibition, was constructed by Sir William Arrol and Co., Ltd.

(To be continued.)

International Conference of Naval Architects and Marine Engineers.

THE International Congress of Naval Architects and Marine Engineers, which took place in London from Wednesday, June 15th, till Saturday, June 18th, will be looked back to by all who were privileged to take part in it as one of the best arranged and most successful congresses of recent years. The excellent and varied programme which was prepared by the Conference Committee under the chairmanship of Sir Charles J. O. Sanders, was carried out in glorious weather, which added to the pleasure of the evening functions and the various social trips. On Wednesday evening, June 15th, there was a pre-conference reception offered to delegates from overseas by Lloyd's Register of Shipping, which was held at the offices in Fenchurch Street. The guests, who numbered between 600 and 700, were received on behalf of the Members of the Committee by the Chairman, Sir George Higgins, and Lady Higgins, and by the Deputy Chairman, Mr. Ernest L. Jacobs, and Mrs. Jacobs. During the evening the string band of H.M. Grenadier Guards played selections of music. Many British guests came on from the conversazione of the Institution of Civil Engineers, and there was time for friendly conversation with friends from different parts of the Continent and the United States of America.

On Thursday morning, at 11.30 a.m., the inaugural reception took place at Grosvenor House, Park Lane, W.1, where the guests were welcomed by Lord Stonehaven, the President of the Institution of Naval Architects, and Lady Stonehaven, and Sir Julian Foley, the President of the Institute of Marine Engineers.

At the luncheon which followed the reception the chair was taken by Lord Stonehaven, who, after proposing the loyal toasts, and the toasts of the Sovereigns and heads of other States represented, proposed a special toast in honour of the King of Sweden, a patron of the Institution, on the attainment of his eightieth birthday. In proposing the health of the visitors, Lord Stonehaven referred to the great pleasure felt by the British members of the Congress in welcoming to London those who had done so much to make memorable the Summer Meetings of the Institution of Naval Architects, which in the years following the war had been held in America, in Italy, France, Belgium, and Holland. Replying to the toast, Jonkheer O. C. A. Van Lidth de Jeude, the President of the Koninklik Institut van Ingenieurs, Holland, congratulated Lord Stonehaven on the honour which had been recently conferred upon him by the King. These periodical conferences were, he said, a valuable stimulus to international co-operation in the technique of shipbuilding, in which Great Britain held a dominant position.

After luncheon, the following papers were read and discussed at Grosvenor House:—"Trends in Shipbuilding," by Dr. James Montgomerie; "Effect of New Safety Regulations in Senate Report No. 184 on the Design of Merchant Ships," by Commander Howard L. Vickery, U.S.N.; "The Present Trend in Marine Engineering in the United States of America," by Mr. John E. Burkhardt; and "Marine Engineering Problems of To-day," by Mr. Sterry B. Freeman, M.Eng. This last-mentioned paper we publish elsewhere in the present issue of THE ENGINEER.

On Thursday evening there was a reception by H.M. Government at Lancaster House, St. James's, S.W.1, when the guests were received by the First Lord of the Admiralty, the Right Hon. Alfred Duff Cooper, and Lady Diana Cooper.

On the morning of Friday, June 17th, the reading and discussion of papers was resumed at the Royal Society of Arts, John Street, Adelphi. The following contributions were dealt with:—"Experimental Methods to Determine the Strength of Materials in Relation to Shipbuilding," by Monsieur H. de Le Leiris; "Whirl of Diesel Engine Crankshafts," by Messrs. G. J. Lugt and N. J. Visser, of Holland; "Ocean Waves, Freeboard, and Strength of Ships," by Professor Dr.-Ing. G. Schnadel; and "Some Contributions to the Theory of Rolling," by Professor Yoshihiro Watanabe, of Japan. We hope to deal with some of these papers in later issues. On Friday morning many of the party took the opportunity of visiting the National Maritime Museum at Greenwich, and embarked in the paddle steamer s.s. "Thames Queen" from the Tower Pier. On arrival at Greenwich they were received by the Admiral President of the Royal Naval College, Vice-Admiral Sir Sidney Bailey, and Lady Bailey, and visited the College buildings and the National Maritime Museum. Luncheon was served in the Museum, by the kind invitation of the Director, Professor Sir Geoffrey Callender, at which Lord Stonehaven presided. After visiting the galleries, tea was served, and the party returned by water to Tower Pier. The same afternoon other members visited the National Physical Laboratory at Teddington, and were received by the Director, Dr. W. L. Bragg, and Mr. G. S. Baker. Visits were paid to the Engineering Department and the William Froude Laboratory, and tea was served in the Laboratory canteen. In the evening a reception was given in the historic Guildhall, London, E.C.2, by the kind invitation of the Right Hon. Lord Mayor, Sir Harry Twyford, Alderman Colonel Richard William Eaton, Sheriff; and Major William Henry Champness, Deputy Sheriff; and the Court of Common Council of the City of London. There was dancing in the Guildhall, and a concert in the Council Chamber, while in the Library were ancient City charters and manuscripts from the Corporation Record Office and the Guildhall Library. The Art Gallery was open and some of the historic plate from the Guildhall and the Mansion House was on view. Buffet refreshments were served in the crypt under the Council Chamber and in the ancient crypt adjoining the Museum, the Court of Alderman Room and the Council Chamber being open during the evening. The Guildhall reception was the outstanding event of the Congress, not alone for the overseas visitors, but for many naval architects and marine engineers, who saw the Guildhall and its rich treasures for the first time.

On Saturday morning a visit was made to Windsor to see Windsor Castle and St. George's Chapel, and after luncheon at the Castle Hotel many of the party travelled by river steamer up the Thames to Henley. On Saturday evening a farewell dinner was given at Grosvenor House by the American delegates to members of the Council of the Institution of Naval Architects and the Institute of Marine Engineers,

who were the visitors' hosts, and Mr. Joseph Powell, the President of the American Society of Naval Architects and Marine Engineers, presented two chairs, one to Lord Stonehaven and the other to Sir Julian Foley, for presidential use at the Institution of Naval Architects and the Institute of Marine Engineers. On Monday, June 20th, many of the party left Euston for Glasgow on a special train. We cannot close this record without some special mention of the excellent work done by Mr. G. V. Boys, Secretary of the Conference Committee, and by Mr. A. Robertson, who was Chairman of the Special Reception Committee for the Guildhall reception.

Newcomen Society.

THE Summer Meeting of the Newcomen Society took place from June 15th to 18th in the Lake District. Surprise may be occasioned that there should be anything of bygone technical interest, such as falls within the purview of the Society to be found there, but when the matter was looked into it was discovered that there were more than fifty industries or trades—minor ones, it may be—that are being carried on or that have been carried on in the district during the past 200 years. The springs of these industries arise from three main causes—first, the area in question is one of high rainfall, hence water power is to be had in plenty; secondly, the countryside is well timbered, hence a number of industries that depend on coppice and other wood can thrive; thirdly, the district is mineralised, so that mining and quarrying can be prosecuted. The ordinary person who visits the district to enjoy its natural beauties rarely sees anything of the industries, for they are carried on in secluded places; a cross section of them can be visualised from the visits enumerated below.

The headquarters of the Society were at Bowness-on-Windermere, chosen not only for its central position, but also because of its natural beauty. Starting on Wednesday, June 15th, the first visit was to the bobbin mill of Messrs. C. and W. Coward, of Stott Park, Finsthwaite, not far from Lakeside Station. Mr. John Coward, whose forebears carried on the business for over a century, conducted the party through the mill. Besides bobbins for sewing cotton and the textile industry, a surprising number of cognate objects are called for. The wood employed is mainly birch, but beech, hazel, and ash are also employed. The timber is about 6in. diameter and a single blank may be turned out of it or a number of bobbin blanks may be cut by a trepanning saw from a cross section of the timber. The blank has a hole bored in it of the size to push on to a feathered quill chuck in a lathe, where cutters mounted in a transverse slide are brought against it and finish the bobbin, which is then automatically pushed off the chuck.

The visitors then drove as close as they could get to Town End Farm, near the hamlet of Elinghearth, where they were met by Mr. Herbert Barker, believed to be now the only remaining charcoal burner in the district. Charcoal burning is a seasonal occupation carried on in the autumn, but Mr. Barker showed the site, explained the method, and took the party to the site of a charcoal burner's hut, where a family would live for six months at a time in the woods. The demand for charcoal is now small, *e.g.*, for box irons, gas absorption, &c. Mr. Barker led the more active members of the party to a "hearth," one of several in the coppice woods hereabouts. These are drystone walled pits some 8ft. or 10ft. diameter at the top, 6ft. to 8ft. diameter at the bottom, where there is an opening, and about 5ft. deep. The purpose of the pits is unknown, but it was suggested that they had been used for burning the branches, &c., after coppicing to obtain ash whence lye—boiled with tallow to make soft soap—was produced in former days. Mr. Barker showed also the method of barking oak timber to get bark for tanning.

Luncheon was taken at Lakeside Hotel, where the glorious view of Cartmel Fells over the lake was hardly noticed till the meal had been despatched.

Resuming the journey, the next place of interest was at Backbarrow on the banks of the river Leven, issuing from Windermere, where a charcoal iron furnace, the last to survive in Great Britain, was visited, under the guidance of Mr. Augustus While. The furnace was established in 1711, as the cast iron lintel which is still preserved shows. The inscription is "I M W R S C 1711," which being interpreted means "John Machell, William Rawlinson, Stephen Crossfield," who were the original partners. In 1870 the furnace was taken over by Harrison, Ainslie and Co., as the existing lintel shows. Blast was supplied by a bellows driven by a water wheel; this was succeeded by a horizontal air compressor, now a stand-by, and later by two Willans engines coupled to Parsons turbo-compressors. Normally the latter are driven by D.C. from a Gilkes turbine, but when the river water is low the Willans engines come into action. The furnace is no longer on charcoal, but is worked with coke, making pig for conversion into malleable iron.

Leaving Backbarrow, for Grange-over-Sands, a pause was made at Low Wood gunpowder works, recently closed down after working since 1799. Previous to that it had been the site of a blast-furnace, and earlier still a bloomery. In one of the storehouses here Mr. Edwin Hughes was making swills—the local name for oak baskets—and he was good enough to give a full demonstration of what is pure handicraft from start to finish. It would take too long to describe the operation in detail, but it may be said that the basket is made of "spells" interwoven with each other. A clever artist like Mr. Hughes will undertake to make a basket that will hold water! The party was dragged away with difficulty, but not till several members had succumbed to the desire to possess a basket each.

After tea at Grange, the Wilkinson monument of cast iron by the roadside in Lindale-in-Cartmel was visited. Originally this monument was erected under the will of the great ironmaster at Castlehead, his country house nearby. After his death the estate passed into other hands, and the monument underwent many vicissitudes till it reached its present resting-place. It was with satisfaction that members learnt that the British Foundrymen's Association is making itself responsible for its upkeep.

In the evening at headquarters, Mr. Rhys Jenkins gave a paper on "The Society for the Mines Royal and the German Colony in the Lake District," very apposite in view of the intended visit on the morrow. It evoked an informative discussion. Following this, Mr. John Somervell, author of "Water Power Mills of South Westmorland," gave a valuable paper on the trades carried on by water power in the Kendal district, in view of the intended visit on the Friday following. Mr. Somervell pleaded that the Society should undertake similar surveys to his own on water mills in other parts of the country.

Thursday, June 16th, was devoted to the mines, the outstanding visit being that to Goldscope (G. Gottesgab =God's Gift) in the Newlands Valley beyond Keswick, where the Germans from Augsburg *temp.* Queen Elizabeth started mining for copper. To get there involved a long coach drive *viâ* Ambleside, over Dunmail Raise, past Rydal, Grasmere, and Thirlmere. Goldscope is difficult of access and from the nearest point to which the coaches could approach, one of the members extemporised a shuttle service with his private car. In this wild spot the outcrop of the lode, an adit level, the refuse from the workings, the tailings from the ore, the ruined buildings, and traces of the water leats were seen.

The return journey was by a longer route, through Keswick, where lunch was taken, past Castle Riggs to see the druidical stone circle (this by request of one of the American members present), *viâ* Troutbeck, Matterdale, to Ullswater. Here an awkward 2 miles' diversion was made to Greenside lead mines, where the party was met by Mr. J. A. C. Friend, manager for the Basinghall Mining Syndicate. The plant is in course of complete overhaul, and a modern froth flotation ore separation plant has replaced the older dressing floors. However, an electric locomotive believed to be the first ever used in a metalliferous mine, certainly over forty years old and not yet out of service, was brought out for inspection and excited the liveliest interest. The visit, which was the first made by an engineering society since the new regime began, was greatly appreciated. Returning to Glenridding, a halt was made for tea and then the journey over Kirkstone Pass to Bowness, and thence to Kendal, was made, as it was there the rest of the programme was to be carried out. No less than seven lakes had been seen, and a more representative tour of Lakeland could not have been chosen.

On Friday, June 17th, starting from the headquarters at the County Hotel, the first visit was paid to the Burneside paper mills of Messrs. Jas. Cropper and Co., where the party was met by Mr. W. A. Willink (director) and his staff. There again everything was modern. The most impressive sight was two 100in. Fourdrinier continuous paper-making machines, one vertically above the other, working in synchronism and combining their laps of paper to form a thick paper, smooth on both surfaces, strong enough when waxed to be formed into the containers with which we are familiar to-day. It was a reflection on our social economy that all this ingenuity is expended on making something that is to be thrown away after once being used.

Coming back to Kendal, Beck Mill, a typical old-fashioned grist mill, was visited by kind invitation of the proprietor, Mr. Gilbert Bethell. The high-breast water-wheel, the four sets of stones driven by it, the drying floor for oats, &c., provided great interest.

Close by an old cotton mill building had been taken over by Mr. W. ff. Gibbs, reconditioned partly as a dwelling-house and partly as a workshop, and there he was making sound furniture and other woodwork.

In the afternoon, to remind members that besides "Kendal green" (cloth) of olden days, the town is celebrated for "Kendal brown" (snuff) to-day, a visit was paid to the Helsington mill of Messrs. Gawith, Hoggarth and Co., by kind permission of Mr. Samuel H. Gawith. The grinding of snuff is done in mortar and pestle mills, as has been practised anytime these last 150 years.

Close by was the engineering shop of Messrs. J. Chaplow and Co., where Mr. Chaplow showed the party his undershot wheel, but the chief point of interest proved to be an old planing machine which appeared to be of the time of Richard Roberts, its inventor.

Returning to Kendal, a pause was made at Force Falls, where the river Gilpin joins the river Kent. The strata here are of limestone, and it was interesting to observe how rapidly denudation could take place there.

Back in Kendal, the works of Messrs. Wilkinson and Co., organ builders, founded in 1829, were visited. The party was received by Miss M. L. Wilkinson, and the art and mystery of organ building was explained by Mr. Austin Jones. The most interesting piece of apparatus was perhaps the "voicing" machine, operated by electric power, possessing two keyboards and having two pressures of wind, so that stops can be adjusted to any desired pressure against a standard set of stops.

In the evening the annual dinner was held, after which Mr. Sidney Mills (member) and his talented friends entertained the company to its great enjoyment.

On Saturday there were still further visits. The works of Messrs. Samuel Gawith and Co. were visited by kind permission of the firm, and besides seeing snuff grinding and blending to suit the nasal organs of every nation, the process of making "twist" tobacco by means of a machine resembling a rope-making machine was seen, among other interesting apparatus.

Throughout the visit the weather was beautifully fine, and everyone departed expressing the liveliest satisfaction with the time spent.

Grid Tariff for North-East England.

THE grid tariff for North-East England, to come into operation on the first of next month, has been issued by the Central Electricity Board. The fixed kilowatt charge in respect of each point of supply is as follows:—For each kilowatt of maximum demand on the Board in the year, being part of the basic demand, £3 10s.; for each kilowatt of maximum demand, being part of the first standard increment, £3 5s.; for each kilowatt of maximum demand, being part of the second standard increment, £3; and for each kilowatt of maximum demand in excess of the basic demand and the two standard increments, £2 15s. The fixed kilowatt charge is, as usual, subjected to variations governed by power factor and rates. If in any year the average power factor of the supply be less than 0·85 lagging during the half hour in which the maximum demand occurred, the fixed kilowatt charge will be increased in that year at the rate of 4s. 6d. for each 0·1 by which the power factor is below 0·85, and a *pro rata* increase will be made for any part of 0·1.

At the end of each year the total sum payable for that year by way of rates in respect of the selected stations in the area of the scheme will be divided by the total continuous maximum rating in kilowatts of so much of the plant in all such stations on January 1st in such year as shall be taken into account in determining the cost of production at those stations in that year. If the sum so obtained be more or less than 6s. 8d., the fixed kilowatt charge will be increased or reduced in that year at the rate of 2s. for each 1s. by which the sum shall be above or below 6s. 8d., and a *pro rata* increase or reduction will be made for any part of 1s.

The running charge for each kilowatt-hour supplied and taken during the year is 0·24d., and is subject to variation as follows:—At the end of each year the total cost of fuel consumed in that year at all the selected stations in the area of the scheme is to be divided by the total number of tons of fuel so consumed, and the average cost of fuel per ton so obtained will be multiplied by 11,600 and divided by the average gross thermal value of the fuel, expressed in British thermal units per lb. of fuel as fired. If the sum so obtained be more or less than 15s., the running charge will be increased or reduced in that year by 0·0009d. for each 1d. by which the sum shall be above or below 15s., ½d. or any greater part of 1d. being treated as 1d.

The table above gives a comparison of the grid tariffs in the various scheme areas, including North-East England.

	Central Scotland.	Mid-East England.	South-East and East England.	North-West England and North Wales.	Central England.	South-West England and South Wales.	South Scotland.	North-East England.
Kilowatt charge—								
Basic demand per kilowatt	£3 10s.	£3 10s.	£3 10s.	£3 7s. 6d.	£3 10s.	£3 10s.	£3 10s.	£3 10s.
First increment per kilowatt	£3 5s.	£3 5s.	£3 5s.	£3 3s.	£3 5s.	£3 5s.	£3 5s.	£3 5s.
Second increment per kilowatt	£3	£3	£3	£2 18s. 6d.	£3	£3	£3	£3
All in excess of above per kilowatt	£2 15s.	£2 15s.	£2 15s.	£2 14s.	£2 15s.	£2 15s.	£2 15s.	£2 15s.
Variations of kilowatt charge:								
(*a*) For power factor, increase of kilowatt charge per 0·1 below 0·85 lagging	4s. 6d.	4s. 6d.	4s. 6d.	4s. 6d.	4s. 6d.	4s. 6d.	4s. 6d.	4s. 6d.
(*b*) For rates, basic rates per kilowatt of plant installed at selected stations	6s.	5s. 3d.	4s. 3d.	4s.	4s.	4s. 6d.	3s.	6s. 8d.
Variation of kilowatt charges per 1s. variation from basic rates	1s. 10d.	1s. 10d.	1s. 10d.	1s. 10d.	1s. 10d.	2s.	1s. 10d.	2s.
Running charge—								
Per unit	0·2d.	0·186d.	0·21d.	0·2d.	0·196d.	0·225d.	0·2d.	0·24d.
Variation of running charge for fuel:								
Basic cost of fuel per ton	13s. 6d.	13s.	16s.	15s.	12s.	14s. 6d.	13s. 6d.	15s.
Basic calorific value of fuel (B.Th.U. per lb.)	11,000	11,500	11,500	11,600	10,000	12,700	11,000	11,600
Variation of running charge per 1d. variation from basic cost of fuel at basic calorific value	0·001d.	0·001d.	0·0008d.	0·0009d.	0·001d.	0·0008d.	0·001d.	0·0009d.

G.W.R. ENGINES NAMED AFTER BRUNEL AND GOOCH.—The memory of two men famous in railway history throughout the world, Isambard Kingdom Brunel and Sir Daniel Gooch, is to be commemorated by the Great Western Railway Company by the naming of engines of the "Castle" class after them. I. K. Brunel was the company's first engineer. He planned and built the line from Paddington to Bristol; was champion of the broad gauge; builder of Box Tunnel and such famous bridges as the Royal Albert Bridge, Saltash, Maidenhead Bridge, and Clifton Suspension Bridge, and designer of the Atlantic liner, "Great Western." Sir Daniel Gooch was the company's first locomotive superintendent, founder of Swindon works, designer of famous locomotives, and later chairman of the company. Both the locomotives are going into service immediately They will be attached to the London sheds at Old Oak Common, and will be used on express services, including the "Bristolian" and "Cheltenham Flyer."

Rail and Road.

AMERICAN TRAIN WRECK.—Early on June 19th the "Olympian" Tacoma–Washington express train plunged into a creek near Saugus, east of Miles City, Montana, as a result of two sections of a bridge being washed away by a cloudburst. It is reported that over thirty people have lost their lives and many have been injured.

A WIDE ROAD AT LIVERPOOL.—Work has begun at Liverpool on what will eventually be the widest road in this country. It will be 160ft. wide and include two 22ft. carriageways, two 9ft. cycle tracks, and a 30ft. central reserve. There will also be plantations bordered by two service roads on one side of the new road, bringing its total width up to 350ft. It will extend for about a mile from the Speke roundabout to the new Liverpool and Widnes road at the county boundary.

ACETYLENE GENERATING PLANT FOR RAILWAY WORKS.—At the Gorton works of the London and North-Eastern Railway Company 158,000 cubic feet of acetylene gas are used for welding and cutting purposes. Most of this gas has hitherto been obtained from seven portable generators, the remainder being purchased in dissolved form. Arrangements have now been made to install a central generating plant with a suitable pipe line system with hydraulic safety and isolating valves. Gorton works were the principal works of the former Great Central Railway Company and are still an important locomotive works of the L.N.E.R.

WOLVERHAMPTON ENGINE SHED MODERNISATION.—The engine shed of the London, Midland and Scottish Railway Company at Bushbury, near Wolverhampton, is to be modernised at a cost of over £16,000. The improvements will include a new mechanical coaling plant, ashpits, and ash-lifting plant; the remodelling of the yard to enable the movements incidental to the preparation and disposal of engines to be performed more expeditiously, as well as improved and additional facilities for watering engines, and better lighting. Bushbury is one of the important L.M.S. motive power depots in the Midlands, the forty-two engines stationed there working to places as far apart as Leeds and London.

FOR the London, Midland and Scottish Railway Company's summer time service, which will come into force on Monday, July 4th, altogether 264 trains are being speeded up, by a total of 989 minutes daily, and many additional trains will be run. From London to Birmingham, a new restaurant car business express will be run (except on Saturdays) at 8.10 a.m. from Euston, making the journey in two hours, and covering the 76¼ miles from Watford to Coventry at an average speed of 62·9 m.p.h., start to stop. The 8.30 a.m. Manchester express from Euston (Saturdays excepted) will convey a portion for Liverpool, arriving there at 12.21 p.m. Sunday travel will also be improved, typical accelerations of Sunday trains being 15 min. from Glasgow to St. Pancras by the 10 a.m. from St. Enoch and 13 min. from London to Manchester by the 3.30 p.m. from St. Pancras. Eight Sunday trains to and from Blackpool will be speeded up by a total of 48 min.

RECONSTRUCTION OF CALDER BRIDGE.—In the early hours of Sunday, June 12th, the new Calder Bridge arrived in Leeds on a special train from Middlesbrough. The train consisted of twelve wagons, each fitted with five wooden bolsters supporting a spandril piece, 55ft. 7½in. long, 14ft. 6in. wide, and 2ft. 2in. deep, and these twelve girders, weighing 175 tons in all, will form the main structure of the new bridge. As the load was too wide for normal railway working, special arrangements were made to move the train from Dorman, Long and Co.'s works at Middlesbrough during the night, arriving in Leeds at 6.30 a.m. on Sunday. Traffic on the adjoining lines was suspended and precautions taken to prevent the girders striking signal posts and other lineside structures *en route*. This is the first stage in the reconstruction of Calder Bridge, which will necessitate the closing of the main line between Hare Park and Wakefield stations, and the diversion of all traffic *viâ* the loop line through Wakefield Kirkgate for a fortnight.

NIAGARA FALLS BRIDGE.—The President of the International Railway Company has announced that work of replacement of the Falls View Bridge, which collapsed in the Niagara River on January 27th last, will shortly begin. Contracts for the excavation of new foundations have already been placed. The foundations will be 50ft. further from the edge of the river on both the United States and Canadian sides, and will be 20ft. higher up the wall of the gorge than the old abutments. The new position will place the bridge well above the highest point ever reached by ice jams and the structure will cost about 1,500,000 dollars. It will be a spandrel-braced arch, 950ft. long, and will carry a 42ft. wide, four-lane roadway with a 12ft. wide pavement for pedestrians at a lower level than the vehicle deck. Later reports state that the Government of Ontario is determined to stop construction of the bridge by a private company as Bills are being promoted by the Canadian and United States Governments for the building of a new structure.

A NEW SWEDISH LEVEL CROSSING WARNING.—The Stockholm correspondent of the *Electrical Review* describes a new application of ultra short-wave radio. He reports that a number of railway engines used on lines that have many level crossings are to be fitted with ultra short-wave transmitters of a predetermined range and a standard wave length. Permanently operating receivers connected to power amplifiers and large m.c. speakers will be installed at the crossings to reproduce a warning note broadcast by the transmitter of the approaching train. The new system has at least one very important advantage over previous safety arrangements, namely, that the warning signal may be timed in accordance with the speed of the train. With the ordinary arrangement of rail contacts the warning signal is given when the train is at a fixed distance from the crossing, but does not take into account the fact that the distance is covered much faster by an express train than by a slow goods train. By varying the range of the ultra short-wave train transmitters according to the normal speeds of various types of trains, the new method makes it possible to give the motorist an exact idea of when a train will pass a level crossing.

Miscellanea.

NEW ZEALAND GOVERNMENT CONTRACTS.—The New Zealand Government announces that contracts valued at £154,000 have been placed with British firms for the supply of equipment for rolling stock, screening plant for coal mines, insulated rail joints, portable cranes, and telephone cable.

IRON AND STEEL IN U.S.S.R.—According to the *Bulletin* of the Russo-British Chamber of Commerce in the United Kingdom, during 1938 it is planned to put into operation six new blast-furnaces with an annual capacity of 2,620,000 tons of pig iron and eleven open-hearth furnaces capable of an aggregate annual output of 1,391,000 tons of steel.

THE WORLD'S COAL OUTPUT.—According to statistics given in a survey of the German Reichskohlenrat, the world production of bituminous coal and anthracite in 1937 is estimated at 1,288,400,000 metric tons. Of this amount, the United States produced 444,600,000 metric tons, Great Britain 245,100,000 metric tons, Germany 171,100,000 metric tons, U.S.S.R. 80,500,000 metric tons and Japan 51,000,000 metric tons.

SAND-BLASTING AND ENAMELLING SURFACES.—In a paper before the Institute of British Foundrymen dealing with sand-blasting as applied to vitreous enamelling, Mr. H. Whitaker suggested that research might be carried out, using varying air pressures and grades of grit, with a view to utilising some of the grades not at present in common use for enamelling. A test should be evolved to ascertain the degree of "pitting" best suited to take enamel.

RED HOT POKER COLD TO THE TOUCH.—With few pokers is it true that when thrust into the fire and quickly heated up to a red heat, they can be handled as close as 6in. from the red hot portion without burning the fingers. It is stated that this is quite feasible with pokers made from "Maxhete" heat-resisting steel, made by Edgar Allen and Co., Ltd. With these, assuming that the poker is quickly heated and not left, say, for half an hour in the red hot condition, the heat conductivity is so small that the fingers can quite safely grip to within 6in. of the red hot tip without any feeling of appreciable heat. This is a phenomenon not often commented upon in notes on heat-resisting steels.

L.C.C. CONTRACT CONDITIONS.—The Federation of British Industries has been informed by the London County Council that it has agreed to modify the clause in the L.C.C. contract conditions for engineering works, concerning which the F.B.I. had made representations to the Council. In the clause in question the Council reserved to itself the right to postpone execution of the work for any cause, without granting the contractor recompense for the extra expense to which such postponement might put him. It was believed that actual cases had arisen where such postponements had led to substantial increased cost to the contractor. The Federation contended that the contractor could not possibly foresee or provide for such eventualities over which he had no control.

GENERATION OF ELECTRICITY.—The official returns rendered to the Electricity Commissioners show that 1854 million units of electricity were generated by authorised undertakers in Great Britain during the month of May, 1938, as compared with the revised figure of 1621 million units in the corresponding month of 1937, representing an increase of 233 million units. The number of working days in the month, *i.e.*, excluding Sundays and Bank Holidays, was twenty-six, as against twenty-four last year. During the five months of 1938 up to the end of May, the total amount of electricity generated by authorised undertakers was 10,341 million units, as compared with the revised figure of 9648 million units for the corresponding period of 1937, representing an increase of 693 million units.

ELECTRICITY SUPPLY (METERS) ACT, 1936.—A communication addressed by the Electricity Commissioners to all authorised electricity undertakers concerning the Electricity Supply (Meters) Act, 1936, directs attention to the Commissioners' letter of January 28th last intimating that they proposed to advise the Minister of Transport to fix May 1st, 1938, as the appointed day for the purpose of the Act. In view of representations which were subsequently received from certain undertakers, however, the Minister, on the advice of the Commissioners, has made orders fixing July 1st, 1938, as the appointed day. The attention of all undertakers is specially drawn to the further explanatory notes which have also been sent to the undertakers, and which should be read in conjunction with the notes previously circulated to them.

AIR DUCTS.—Owing to structural peculiarities and limitations, or to changes in the quantity of air being carried, changes in the cross-sectional area of ducts conveying air frequently become necessary. In designing duct systems data on the pressure losses resulting from such changes are necessary in order to evaluate the total resistance to the flow. An investigation which is described in a bulletin, "Pressure Losses Resulting from Changes in Cross-sectional Area in Air Ducts," by A. P. Kratz and J. R. Fellows, which has been issued by the Engineering Experiment Station of the University of Illinois, had for its object the determination of the losses in total head or total pressure, otherwise called "shock loss," resulting from abrupt changes in the cross-sectional area of an air stream, or occurring in various transition sections connecting ducts of different diameters. Among the conclusions reached are the following:—The shock losses in abrupt contractions are much smaller than those caused by abrupt expansions. The shock losses in diverging sections are dependent on the angle included between the sides of the section, the smaller losses occurring with the smaller angles; and the loss with an included diverging angle greater than 60 deg. is as great as that occurring with an abrupt expansion. The shock losses in converging sections are also dependent on the angle included between the sides of the section, the smaller losses occurring with the smaller angles; and the loss with an included converging angle of 60 deg. is less than that in an abrupt contraction.

Air and Water.

A RECORD AIR LINER FLIGHT.—A new Savoia-Marchetti air liner of Sabena has made a record flight from Croydon to Brussels by covering the 200 miles in 50 min.

NEW AERODROMES.—The new municipal aerodrome at Luton will be officially opened on July 16th, and the Ringway aerodrome at Manchester on June 25th.

THE "CUTTY SARK."—The famous China tea clipper "Cutty Sark," has been placed astern of the naval cadet training ship, H.M.S. "Worcester," at Greenhithe, where she will be used with the latter as a cadet training ship.

NEW DIRECTOR OF TECHNICAL DEVELOPMENT.—An Air Ministry announcement states that Air Commander R. M. Hill has been appointed Director of Technical Development, Air Ministry, from August 1st next. Since September, 1936, Air Commander Hill has served in the Department of the Air Member for Supply and Research.

LONDON'S SHIPPING.—During the week ended June 10th 1131 vessels, representing 1,049,707 net register tons, used the port of London; of these, 505 vessels were to and from Empire and foreign ports, and 626 vessels were engaged in coastwise traffic. Forty-eight ships, totalling 440,425 tons gross register, used the Tilbury landing-stage during the month.

ABERDEEN HARBOUR REPAIRS.—A scheme of repairs to the south breakwater of Aberdeen Harbour, at an estimated cost of £80,700, has been approved by the Harbour Board. A breach was torn in the breakwater by storms, and repairs made last year cost over £30,000, and the resultant strain and deterioration has necessitated further extensive works to prevent future damage.

THE NAVY HYDROGRAPHIC DEPARTMENT.—The annual report of the Hydrographer of the Navy states that during 1937 a total coastline length of 667 miles was surveyed and an area of 6599 square miles was sounded. Of the seven ships employed, three were in home waters and four abroad. Four new ships are under construction for the service in home waters and two for foreign stations, in addition to the "Research," which was begun in September, 1937.

SEA BORNE COAL AND LONDON.—At the launch of the London Power Company's new collier at the yard of S. P. Austin and Son, Ltd., Sunderland, Sir Leonard Pearce said he did not think it was fully appreciated that something like 4,000,000 tons of coal was brought by sea to London every year for the use of electricity stations in London. Since the London Power Company embarked in 1933 on the policy of building its own ships for carrying coal to its power stations, it had bought 3,700,000 tons of coal from Scottish, Welsh, and North-East ports.

NEW AMERICAN CARGO SHIPS.—The United States Maritime Commission has placed an order with the Newport News Shipbuilding and Drydock Company for the construction of four standard steam propelled cargo vessels of the C 2 design. The new ships, which will cost over 2,000,000 dollars each, will be 435ft. long, with a displacement of 13,900 tons and a speed of 15½ knots. This speed will make them over 50 per cent. faster than the majority of the cargo ships in the U.S. Merchant Marine at the present time. It is stipulated that all the vessels must be completed within 600 days.

SEA ACCESS TO THE SUEZ CANAL.—In his speech at the annual general meeting of the Suez Canal Company, Monsieur le Marquis de Vogüé said that difficulty was being experienced with the channel which gives access from the open sea to the port of Port Said. The 39ft. depths corresponding to the average depth of the Canal are only found at more than 5 miles from the shore, and tend to become more distant. It has been decided, in agreement with the Commission Consultative Internationale des Travaux, to try a more modern type of dredger for maintaining a channel from the sea to the Canal. The new type of dredger has been successful elsewhere.

THE FLYING BOAT ACCIDENT AT ATHENS REPORT.—The report on the inquiry into the cause of the accident to the Imperial Airways flying boat "Courtier," at Athens, on October 1st, 1937, says that the pilot was apparently misled by the smooth surface of the sea and by the phenomenon of reflection characteristic in such circumstances. The cause of the accident is attributed to error of judgment by the pilot, who did not make a circuit before landing to estimate his height by means of buoys or the coast line. He did not flatten out the machine, and it touched the water at a steep angle and comparatively high speed, causing considerable damage to the hull.

SHIPBUILDING PLANS IN THE UNITED STATES.—In the course of a recent address in New York, Admiral E. S. Land, Chairman of the United States Maritime Commission, said that to replace that country's ageing mercantile fleet it would be necessary to build 261 vessels a year for the next five years. Such a programme would entail an expenditure of about 2500 million dollars and the country had neither the funds nor the facilities for such an undertaking. Plans have been prepared to build for the country's minimum needs, and a careful survey of the requirements of the commercial and national defence interests has shown that minimum needs call for 500 new vessels in the next ten years. The cost of this building programme is approximately 1250 million dollars, and, said Admiral Land, is within the country's capabilities.

CIVIL AERODROMES AND THE R.A.F.—As already announced, the Air Ministry has for some time had under consideration the possibility of making further use for Royal Air Force purposes, of the facilities available at civil aerodromes throughout the country. At a number of such aerodromes, both municipal and privately owned, various Auxiliary and Reserve units and training centres have been established, and landing rights and other facilities made available for Royal Air Force purposes, without restricting the normal use of the aerodromes for civil aviation purposes. A comprehensive review of the possibilities of all civil aerodromes has now been put in hand, in order to ensure that, wherever practicable, Royal Air Force requirements will be met by making the fullest use by arrangement with the owners, of facilities there available.

THE LUTON WORKS OF GEORGE KENT, LTD.

(*For description see page 716.*)

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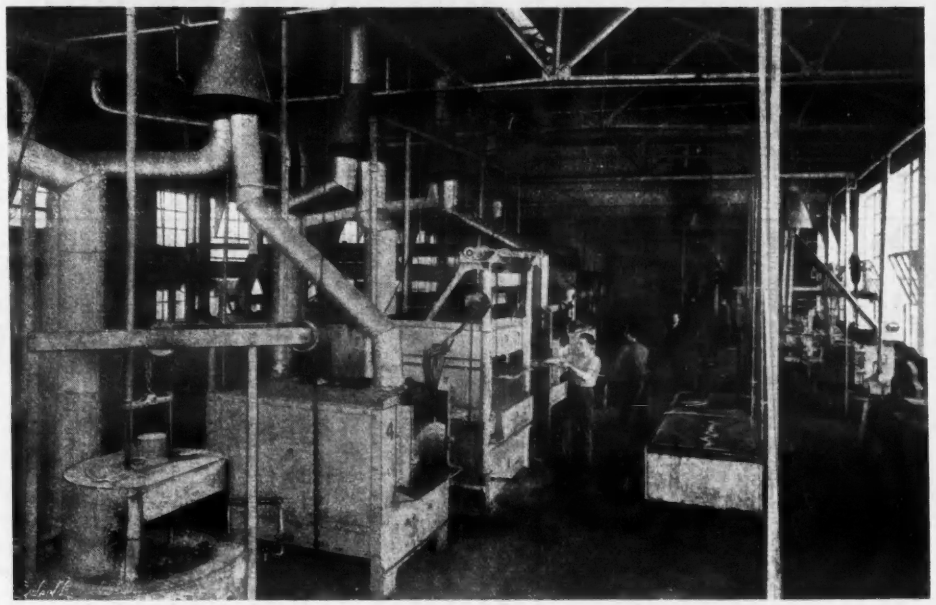

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SIXTEEN-PAGE SUPPLEMENT—"THE METALLURGIST."

NOTICES TO READERS.

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CHANGES OF ADDRESS.

*** Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

The Metallurgist.

THE JUNE NUMBER OF
THE METALLURGICAL SUPPLEMENT TO
"THE ENGINEER" ACCOMPANIES THIS ISSUE.

PROBLEMS OF A MARINE SUPERINTENDENT.

IT is all too seldom that we get such papers as that which Mr. Sterry Freeman read at the International Conference of Naval Architects and Marine Engineers last week. Most of the contributions to technical institutions deal with the successes of enterprise and pass lightly, if they touch upon them at all, over the failures, disappointments, difficulties, and problems which environ the practical engineer. Sometimes a corrective is supplied by the discussions, but more often than not differences of opinion or experience are so tempered by a desire to be polite to the author that their value is diminished, whilst at other times members who might present the other sides of cases do not attend the meetings, or remain silent on one pretext or another. Thus it comes about that discussions which should be critical, and which are of relatively small value if they are not, are carried on chiefly by those who are prepared to corroborate the author's statements. In fine, the tendency of discussions is generally—not always—to overlook and smooth away tribulations and to minimise the problems and difficulties which present themselves. Mr. Sterry Freeman, who speaks with unsurpassed knowledge and experience of marine engineering, puts before us in his paper, reprinted elsewhere in this issue, the problems that beset a marine superintendent of a large fleet. He does no more than outline them, but there is not a single one of his problems which would not form a profitable subject for an untrammelled and open debate. They cover the whole gamut of marine engineering as it presents itself to one who is responsible for the operation of many ships, and they show that there is scarcely an element in the power equipment of vessels which does not still leave a good deal to be desired.

Very early in his paper the author raises the questions of efficiency and after remarking that "there is always a danger that more may be spent in first cost than is saved in subsequent economy," adds "It should be emphasised that the eternal search for efficiency is always right and to the good—it is the cost of achieving it that is the important qualification." There we see the man whose first responsibility is to ensure that his ships are run economically as well as one who, speaking as an engineer, cannot forget that it is his constant duty to seek for the improved efficiency of machinery. The problem presented is a difficult one. How far is a marine superintendent justified in spending more for extra efficiency than he can hope to recover in economy of operation? A hasty view would be that he would never be justified in spending a penny piece if he could not see a penny piece and a fraction in return. But if everyone followed that line the chances of attaining both greater efficiency and greater economy would be reduced to the vanishing point. The marine superintendent, like any other engineer responsible for plant, must encourage inventions—even if it entails a temporary loss—in the hope of future gain. And invention is only to be encouraged by trying things. No mechanical engineering problem was ever settled wholly on paper, and with all deference to Mr. Freeman, very few of them on the test bed. "It is regrettable," he writes, "that so far no means of running test-bed trials of large steam plant are available to ascertain with certainty the relative economy of, for example mechanical and electrical transmission of power." We confess to considerable doubt that the test bed could answer a question of the kind. It is the right place to seek for scientific results, but an untrustworthy guide to economy. Mr. Freeman himself shows us how true that is by a dozen references to the detail troubles that face the operating engineer—metals that will not unfailingly resist high temperatures and pressures; the distortion, cracking, and eroding of turbine casings; leaking packings; broken blades; oil in the feed; water in the fuel oil; disalignment of shafting owing to changes in a ship's structure; failure of the piston rings of cylinders of oil engines, and so on. In fact, very many of the "problems" which Mr. Freeman puts before his readers are problems associated with the maintenance, and therefore the economy, of machinery. Not until a multi-millionaire provides his country with a test bed that will simulate all the motions and conditions of a ship at sea in all weathers, and will endow it with funds sufficient to pay for runs equal to half a dozen round trips shall we be able to answer on shore the economic problems associated with marine engines. Our respect for test beds is great, but we recognise that in all cases they have their limitations and perhaps in none so much as in marine engineering. Indeed, it may be said with a great measure of truth that the whole of Mr. Freeman's paper goes to prove that the problems with which the marine superintendent has to contend are just those which do not present themselves save under actual operating conditions and can only be answered after prolonged experience.

It was our intention to indicate in this article some of the matters with which Mr. Freeman dealt in order to whet the appetite of the reader so that he might ask for more; but we fear we have been deflected from our purpose by the attraction of one or two items. We are afraid, too, that if we started all over again we should find ourselves not giving our readers a general impression of the paper, but loitering over two or three of the author's problems. Take, for example, his comments on invention, or his remark that "mechanical grates work well, but when a suitable coal is found for use with these, the price of that coal promptly tends to go up." It would be difficult to resist the temptations to enlarge on such things. Or, again, consider what he has to say about the factor of safety of tank boilers, or this: "If one firm has a monopoly of the manufacture of a successful engine, then all the other firms are tempted to decry that firm's engine, which does not help co-operation." To the leader writer, such texts are "jam," and we are confident that did we try a score of times to steer between the many themes which the author has set up we should find ourselves halting at one or two and neglecting the remainder. Our best advice to our readers is to turn to the original. We shall be surprised if, having begun it, they can leave it till the last word is read.

On Being Clever.

IN an after-dinner speech to the Engineers' Club of St. Louis, a few weeks ago, a speaker stressed the "advantage of not being too clever." He held that too much knowledge bred an excess of caution; that too keen a perception of the liability to error paralysed action, and that too much study and investigation led to "an exaggerated notion of the impracticableness or impossibility of attaining the desired end." With this view we have much sympathy. It is often better to do something and fail than to do nothing for fear of failure. There is an old and familiar story about Edison when he was searching for a filament for incandescent electric lamps. He had spent a long day with a negative result, and a visitor condoled with him on the wasted time. He replied that it was not wasted, for he then knew what would not work. That is very useful knowledge. In mechanical engineering especially nothing is certain until it has been tried—except the absolutely safe or the absolutely foolish. However faint the promise of success, it should be followed if the end is worth attainment. The drawing-board is excellent up to a point, but it never teaches so much as the thing itself. If Parsons had waited till all the problems of the steam turbine had been settled on paper, someone else would have anticipated him. His first machines were mechanically wrong in a hundred ways and devourers of steam. But they were good enough to show him that the principle of 'compounding' was sound, and that was what mattered. Step by step he improved the design by meeting the difficulties as they arose. The rapid advance of the steam turbine in its early years was due in a much greater degree to Parsons' intuitive mechanical sense than to what one might almost call its 'intellectual' development.

But whilst these considerations lead us to agree with our after-dinner speaker that too much thought may delay action, we would qualify his statement "that most of the great feats of engineering, the marvellous achievements that have excited the wonder and admiration of mankind, have sprung from the brains of men who were not very well versed in the technical knowledge necessary for the detailed designing of the project." If that assertion were substantially true, we should logically be compelled to encourage those who had no knowledge of the science of engineering rather than those who had. But, in fact, it cannot be supported by sound evidence. It is true that a certain number of notable ideas have sprung up in the minds of non-technical inventors. But, speaking generally, the inventors have lacked the ability to carry them out, and have had to seek the assistance of trained intellects. The number of such inventions is, however, very small by comparison with the effective inventions of those who have studied their subject either theoretically or practically or both. We doubt if our speaker could have named a dozen genuine instances in support of his assertion. There are cases which at first sight would appear to support him—Newcomen an ironmonger, Armstrong a lawyer, Fulton an artist, and so on—but on examination it will be found that these inventors had, in fact, made themselves masters of such information as existed at the time. If we attempted to set against these names a list of the engineers who were responsible for important inventions a page would not hold it. Even the pioneers—Newcomen, Watt, Hedley, Stephenson, Trevithick, Oliver Evans, and many others in other fields who had but little to guide them—were not wholly without experience. They did not rush in with the courage of ignorance, but with the guidance of such knowledge as they already possessed or were able to secure. Hedley, Stephenson, and Trevithick, all mining men, knew something of machinery before they attacked the locomotive, Newcomen had a practical knowledge of pumping as well as familiarity with tools acquired at a time when the ironmonger was a practical man as well as a salesman. Watt was a surveyor and instrument maker, and was trained in the use of tools. Oliver Evans began as a wagon builder. If we turn to later years, we find that such leaders as Otto, Diesel, Parsons, and practically all those associated with electrical engineering were qualified engineers or scientists. Even Westinghouse and Edison, though they were not technically trained

in the modern sense, had by their predilections and occupations prepared the way for their subsequent work. It can only be said of them that "they were not very well versed in the technical knowledge necessary for the detailed designing of the project," if we qualify the statement by adding that the knowledge did not exist anywhere.

Yet despite this criticism of the precise words of the after-dinner speech—which, like its kind, should perhaps not be read *au pied de la lettre*—we are in accord with the spirit by which it is inspired. Knowledge, even scientific knowledge, is a dangerous thing if we imagine that it is complete, when, in fact, it is not. That is, by no means, an exceptional state of mind. From the necessity of the case, teaching has to be positive, and the student leaves college with very definite fixed ideas. The better he has been taught, the more rigid will those ideas be. He knows, or believes he knows, what can be done and what cannot be done, and at that stage of his career is intolerant of all who take a more liberal view of the restrictions imposed by science. To put it another way, his imagination is in prison. It is confined on all sides by a network and grille of rigid laws; he will not, or cannot, allow it to indulge in flights of fancy. The less rigidly educated man finds loopholes through the laws, and may blunder, so to speak, on something that is worth doing. Or, on the other hand, we may find men well educated in whom the imagination has not been stultified, and who break through the laws with the help of the laws themselves. They are the best of the scientific inventors. Years ago John Bourne wrote: "There will be fewer errors committed as mankind becomes more learned, but there will also be less originality and adventure." We suspect there is a good deal of truth in that saying.

The Institution of Civil Engineers.

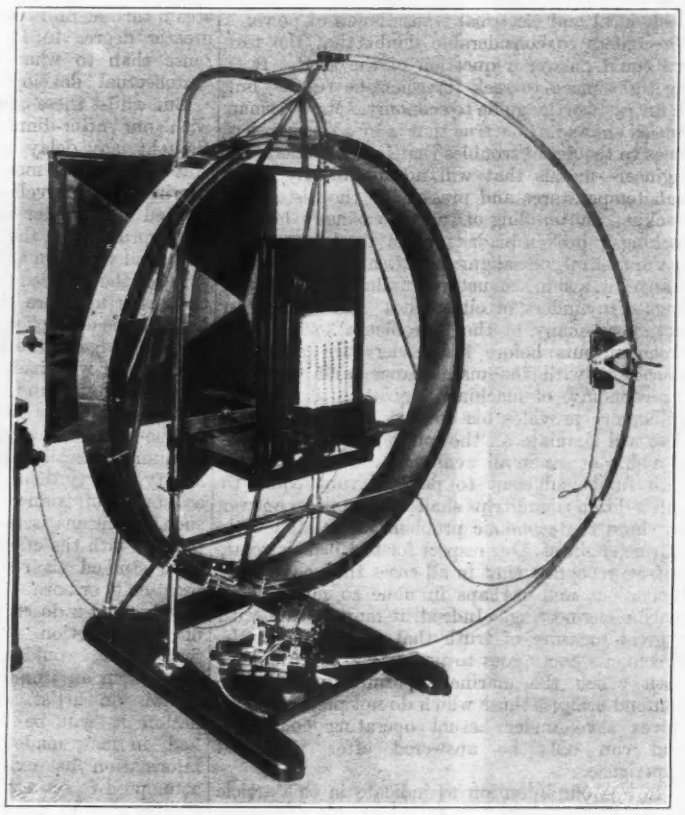
ANNUAL CONVERSAZIONE.

"CONVERSAZIONE" is still the official name which is applied by the Institution of Civil Engineers to the function which it holds annually at its home in Great George Street. It is doubtful, however, whether the name is now as fully appropriate as it was in years gone by, when the number of guests attending the function was smaller and the arrangements made for their entertainment were less lavish than they are to-day. The Institution building, spacious as it is, is taxed to accommodate the three thousand or so guests who now annually crowd through its portals on conversazione night. Moreover, with an almost continuous programme of lectures and orchestral and other music, little interval is left for serious conversation and discussion. Further, it must be admitted that the attractions of the well-stocked refreshment rooms militate seriously against indulgence in learned discourse as between one guest and another, while the gay decorations, floral and otherwise, are remote from the sober spirit of scientific surroundings. We cannot picture Einstein at work in a conservatory or Newton expounding the theory of gravitation to the strains of "Snow White and the Seven Dwarfs." For ourselves, we made no attempt on Wednesday of last week to wrap ourselves in the heavy garb which befits an austere occasion, but, with the great majority of the guests, gave ourselves over to the dignified enjoyment of a light-hearted evening.

Of the lectures which were arranged as usual within the compass of the evening's programme, that by Mr. L. H. Pomeroy on "Motor Car Gears" was perhaps the most serious. Professor C. E. Inglis, in his lecture on "Suspension Bridges, Ancient and Modern," succeeded in amusing as well as instructing his audience. Dr. R. E. M. Wheeler, in his graphic lecture on "The Maiden Castle Excavation," had an engaging subject which, although it was staged at a late hour, enthralled the large gathering which flocked to hear his discourse.

In the main library and elsewhere numerous exhibits of engineering and technical interest were, as usual, arranged for the occasion, and served as a pleasant foil to the sweet sounds, sights, and tastes to be enjoyed elsewhere in the building.

Among the exhibits we noted an integrating radiometer for measuring the radiant efficiency of domestic gas or solid fuel fires or electrical heaters. This apparatus, illustrated herewith, was shown by Mr. B. E. Martin, and was devised in the research laboratories of Radiation, Ltd., of London. It consists, as will be gathered from the engraving, of a ring frame within which the fire is centrally mounted, and a semi-circular arm which can be rotated through 180 deg. by a small motor attached to its lower pivot. This arm carries one or more radiant heat-measuring units, each formed of a copper block with a thermo-couple attached to it. As the arm rotates the copper block becomes heated by radiation from the fire, the total heat acquired during the movement being indicated on a galvanometer connected to the thermo-couple or couples. In the apparatus as shown at the Conversazione, seven or eight radiometer units were mounted on the semicircular carrier, and were connected in series with the galvanometer, the reading of which at the end of a transit gave a measure of the total amount of heat received by all the radiometers during their movement across the path of the heat rays from the fire. A detailed description and discussion of this equipment was given in a paper by Mr. A. R. Bennett and Dr. Harold Hartley, presented before the Institution of Gas Engineers on November 4th, 1936.



INTEGRATING RADIOMETER

One of the exhibits of the Building Research Station was a model of the equipment used in the investigation of the strength of bridges, now being conducted for the Ministry of Transport. The model shown represented the old stone Croft Bridge at Derby. On the road surface over each abutment a timber crib was erected to support two longitudinal steel girders spanning the bridge. These girders were loaded on top with a pile of lead weights. This load or any proportion of it could be transferred to the crown of the arch through a 75-ton proving ring, and hydraulic jack, placed between the underside of each steel girder and the road surface. To measure the deflection of the bridge under the applied load, series of deflectometers were arranged beneath the arch. Each deflectometer consisted of a free-running weighted piston inside a cylinder, the weight of the piston being taken by a wire attached to the undersurface of the arch, and its movement being measured by means of a Mercer or Ames dial, graduated to 1/10,000 inch, placed beneath the piston. Three rows of these deflectometers were arranged beneath the span, each row consisting of eight deflectometers. Similar deflectometers were employed to measure the spread of the span and any rotation of the abutments which might occur under the applied load. A development of the arrangement was also exhibited. It consisted of an automatic deflectometer whereby the deflection of the arch at any point while a load was moving across the bridge could be recorded graphically.

Another exhibit shown by the Building Research Station consisted of an electrical device for measuring the maximum horizontal component of acceleration in the placing of concrete by vibration. Part of the apparatus consisted of a small brass box at the end of a rod. The rod was intended to be inserted into the batch being mixed with the brass box downwards. Inside that box there was a contact which was held in the "on" position by the pull of an electro-magnet of measurable strength. Under the force of acceleration imparted from the batch to the box, the contact would be periodically broken. The rest of the apparatus consisted of equipment for varying and measuring the strength of the electro-magnet, and a neon lamp. To measure the acceleration the magnet strength was adjusted until the neon lamp just ceased to flash.

Some exhibits by Sir Robert Hadfield illustrated recent advances in metallurgy, and new testing methods. One of the exhibits related to a test for the fluidity of molten steel, as cast at various temperatures. The test consisted of pouring the steel into a sand mould of standard dimensions, consisting of a conical header, from which a straight round passage about ¼in. diameter extended for a length of about 18in. The fluidity was measured by noting the extent to which the steel flowed along this passage before solidifying. Each test required a new mould, but we were assured that the moulds can be quickly and cheaply made to standard dimensions and characteristics.

SUBSTITUTE FOR "T" BRANCH PIPE

Another of Sir Robert's exhibits consisted of a set of eight scratching tools covering a range of hardness extending from 550 to 930, as measured by a diamond pyramid. The tools are used for measuring the scratch hardness of metals in practical cases when the ordinary methods of determining hardness are difficult to apply. They enable the hardness to be assessed within average limits of 50 units. The procedure is to endeavour to scratch the specimen with the tools in succession until two successive tools are found, one of which will not and the other will scratch the metal.

In connection with Mr. Pomeroy's lecture, exhibits were shown illustrating the construction of the Hayes self-selector transmission, the Leyland hydraulic torque converter, and the Vauxhall three-speed gear-box. Of similar interest were exhibits shown by the Automobile Research Committee of the Institution of Automobile Engineers. These exhibits illustrated the equipment employed by the Committee on three current investigations, namely, the fatigue failure of crankshafts, gear wear and durability, and engine-bearing temperatures. The object of the gear wear and durability research is to study the wear and pitting on a range of gear steels, machined by various methods, and using a wide range of lubricants. In the gear-testing machine two pairs of gears are run in the form of a closed train, an initial load on the gears being introduced when the machine is at rest by unbolting the flanges of the loading coupling, twisting them relatively, and bolting

together again. A torque of 2700 lb.-inch can be applied, which, when the shafts are driven at 3000 r.p.m., results in 128 H.P. being transmitted through each gear pair, the 4 H.P. driving motor supplying only the friction and other losses. Lubrication of the gears and bearings is by oil under pressure from an independently driven pump, the circuit including an oil filter, an oil cooler, and an immersion heater in the reservoir tank for controlling the temperature. An involute testing instrument is used for measuring the gear profiles before and after testing. Gears which failed by tooth breakage, by scuffing, and by pitting were shown.

An exhibit which if not of strictly engineering interest could claim at least to be descended from an engineering invention was the "theracoupler" shown by the Marconi-Ekco Company. This appliance is an electro-therapeutic device used for the treatment of deep-seated sprains, rheumatism, and other aches. It operates on the same principle as that of the electric induction furnace used in steel making. The surface of the skin and the fatty layers immediately below it are bad conductors of heat, but readily permit the passage of electro-magnetic flux, which, penetrating to the deeper-seated muscular tissues and ligaments, heats them by induction. The "theracoupler" consists of an apparatus which feeds an alternating current through a circuit, one part of which consists of a conductor enclosed in a flexible rubber tube. This tube may be wound round the limb to be treated or simply coiled and laid on top of it. It is immaterial whether the limb is clothed or uncovered. The treatment is pleasant, and, from a trial application of it to a sprained wrist, we are quite prepared to believe that it is effective.

An exhibit by Mr. W. H. S. Aplin, illustrated herewith, showed a simple substitute for a normal T piece in pipe lines. The device consisted of a circular ring formed with holes to permit it to be bolted between the flanges of two adjoining pipe lengths. Over one half the ring was drilled with radial holes lying between the bolt holes. Round the corresponding half of the external periphery a tube with closed ends was welded. This tube was formed to connect with the radial holes and was provided with a flange for coupling it to the branch pipe.

The same exhibitor also showed a water softening plant, which was claimed to give complete de-aeration and zero hardness. The process employed was divided into three stages—a thermic stage, an alkaline presoftening stage, and a trisodium phosphate stage.

The Institute of British Foundrymen.

AS usual, an excellent and well-balanced programme of meetings (for the discussion of papers on practical and scientific subjects), visits to works, and social functions was arranged for the annual meeting of the Institute of British Foundrymen, which was held in Yorkshire (Bradford) last week. The responsibility for the arrangements lay with the West Riding Branch of the Institute, with the co-operation of the civic, industrial, and academic interests of the district.

The annual report of the Council, which was adopted at the annual general meeting, held in the Bradford Technical College on Tuesday evening, June 14th, covered the year to April 30th, 1938, and showed that the year had been one of the most successful in the history of the Institute. The membership has reached 2220 (there has been a steady increase from 1700 in 1935), the finances are in a sound condition, and every department of the Institute's work has made progress.

A year ago Mr. C. W. Bigg (the retiring President) announced the presentation by his co-directors of Qualcast, Ltd., and himself of a sum of £500 to form the nucleus of an endowment fund for the promotion of the work of the Education and Technical Committees. The fund is known as the Technical Development Fund, and it is hoped to add to it substantially in the future.

The Oliver Stubbs Medal (for distinguished service to the Institute) has been awarded for 1938 to Mr. S. E. Dawson (East Midlands Branch); and the E. J. Fox Gold Medal for 1938 (for outstanding contributions to the progress of the foundry industry) has been awarded to Mr. J. E. Hurst, of Sheffield, a Past-President of the Institute.

Mr. E. J. Fox (managing director, Stanton Ironworks Company, Ltd.) was elected an honorary member of the Institute.

Mr. W. Blake (Messrs. Lake and Elliott, Braintree, Essex) was elected Senior Vice-President, and Major R. Miles (Head, Wrightson, Ltd., Thornaby-on-Tees), was elected Junior Vice-President.

Mr. H. Bunting (Derby), Dr. A. B. Everest (London), Mr. J. W. Gardom (Birmingham), Mr. B. Hird (Cardiff), and Mr. F. K. Neath (Leeds) were elected to fill vacancies on the Council.

The President's Address.

Mr. Joseph Hepworth, in his presidential address, discussed some of the changes and developments in the iron industry and in engineering generally in Bradford, for the occasion was the first on which the Institute had held an annual conference there. Bradford had the distinction of being the birthplace of the highest grade of iron in the world. A village now within the city boundary had given its name to Low Moor iron. In addition to the Low Moor Iron Company, other firms in the district, *i.e.*, the Bowling Ironworks at Bradford, the Farnley Company, Cooper Bros., and the Monkbridge Company at Leeds, had embarked on the manufacture of that class of material under the name of "Best Yorkshire Iron." He described the early works of the Low Moor Iron Company, which had its inception in 1789, and the Bowling Ironworks, which were established a few years earlier, both of which had undoubtedly influenced the local engineering industry to a considerable degree, inasmuch as many of the founders of other firms in Bradford had served their apprenticeship at one or other of those works. He mentioned also the development of some of the other firms during the present century.

It was a curious fact that, with the exception of looms, the machinery in the Bradford trade was obtained almost entirely from sources outside the city, and many advantages would accrue from the encouragement of the machine making branch of local engineering. Success depended, however, on a prosperous textile industry, which was itself a matter of conjecture for the future.

Discussing Empire trade, the President emphasised that the Empire possessed as a buying power a population of 500 million people. The Empire overseas bought more goods from this country than the rest of the world, in addition to buying 209 million pounds' worth of foreign goods. If our export trade was strong and healthy our foundry industry was bound to be in a healthy condition. The world was by no means a saturated market, especially within the Empire.

Cement Moulding.

Mr. F. W. Rowe (of David Brown and Sons (Huddersfield), Ltd.), was the author of the first paper presented to the conference. He described the Randupson process of cement moulding, invented by a French engineer, Monsieur Durand, of the Cie. Randupson, Marseilles, and developed, particularly with regard to the special technique necessary, by the Société d'Electro Chimie d'Electro-Metallurgie et des Aciéries Electriques d'Ugine (which owns the world rights) at Ugine, in the South of France, during the past seven years. The process consists in the use of silica sands bonded with ordinary Portland cement and water, in place of the more usual moulding sands. The sand-cement-water mixture is rammed round patterns mounted in wooden box parts or in core boxes, or strickled in the manner usual with loam sands. The sand is reinforced at various points with straight irons, and staples are embedded where necessary for lifting. The resulting moulds or cores are set aside to harden for periods varying from twenty-four to forty-eight hours, and blacked if necessary; the various parts are then clamped together and cast without any surrounding box parts. The moulds or cores after setting have great mechanical strength and very high permeability. After casting, the moulds are stripped in the usual manner and the sand crushed, de-silted, and stored for use over again.

It is essential to preserve a certain well-defined ratio between the amounts of water and cement used, to ensure the high permeability which is the outstanding feature of the process. Normal methods of permeability testing are of little value for the Randupson mixtures, since the permeability is much higher than that obtained with other types of moulding sands. To ensure the essential high permeability the proportion of water added to the cement-sand mixture must be such that the cement is subhydrated only. In practice the actual proportions of cement and water used depend very largely on the type of casting being produced. Large tonnages of carbon and alloy steels, cast iron, gun-metal, phosphor-bronze, and manganese-bronze, aluminium alloys, and magnesium alloys are being cast by this process, in weights varying from a few pounds to 30 or 40 tons. Experience has shown the variations needed to get the best out of the process for the varying conditions.

The author discussed sand considerations, steel foundry conditions, and mould making, and gave an indication of the disadvantages as well as the advantages of the process. The disadvantages are the time needed for setting and the space occupied by the moulds during the setting time (in practice, no mould is cast until two days after making, except in special cases and rush jobs, which can be stove set ready for casting in six hours); all sand used must go through the mixing plant, and all old sand must be regenerated with fresh cement; the sand will not last for more than from three to five hours between mixing and use (dependent on shop temperature conditions and the exact mixture); and the cost of the sand, because it has to pass through the mill and to receive new cement additions each time, is greater than that of normal sands used in iron or bronze founding practice. In steel founding the sand costs on Randupson are about the same as with the old methods, or in some cases cheaper.

The advantages are that no drying stoves and no fuel are needed; there are no box parts and no storage space is needed for box parts; the castings, either iron, steel, or bronze, are much truer to pattern, there being no swells and much less warpage; there is no scabbing; and with suitable sand and working of the process there are no blow-holes; and, the one which counts most in practice, actual moulding times (not including putting together, coring up, &c., which are the same as in ordinary practice) are reduced from 50 to 300 per cent., whilst overall labour times are reduced from 30 to 75 per cent. Much less skill is required, there being no sprigging, venting, or careful ramming.

The author expressed the view that the process is bound to spread rapidly, not only on account of the quality of casting produced, but on account of the ease and cost with which such castings are produced.

Relief of Internal Stress in Castings.

A paper on this subject was contributed by Mr. L. E. Benson and Mr. H. Allison, of the Metropolitan-Vickers Electrical Company, Ltd., who stated their experience that distortion of castings and forgings during machining was in the main, not due to "machining stresses," *i.e.*, stresses set up during machining, but to internal stresses initially; and that with proper annealing beforehand, such distortion on machining could be avoided, except, perhaps, for special work demanding very close limits. This paper will be reproduced in a later issue.

English and American Steel Foundry Practice.

An interesting paper by Dr. C. J. Dadswell, of the English Steel Corporation, Ltd., was the result of a visit to America, where the steel foundry industry is very much specialised as compared with that of Great Britain. Similar castings were being made in different parts of America by different concerns, and the methods used were very similar, even in detail, partly owing to the interchange of information, which in recent years has become more common, between manufacturers of similar castings. There was a marked difference between America and England regarding the categories of size and weight into which castings were divided for making in green sand, skin-dried or dry sand. There was also considerable difference in the kind of moulding mixtures employed for the different sands, the difference in material being most marked in the case of American dry sand, which with very few exceptions was of the synthetic type for all sizes of castings. One of the striking features of American steel foundry practice was the extent to which green sand moulding was practised. Apart from its being almost universally used for machine moulding, it was common to find jobbing castings up to 5 tons being made in it, and up to 25 tons by the skin-dried method. Nothing like the same proportion of green sand moulding was done in England, though it was coming into more favour every year. The reason why green sand moulding had developed to a far greater extent in America than in England was no doubt the large-scale production in America, as green sand was the only logical method for large outputs.

The most common steel melting unit for the small foundries was the electric furnace, usually with an acid lining, as against the almost universal basic lining in this country. For larger outputs both acid and basic open-hearth furnaces were used, commonly fired by oil or natural gas, occasionally by producer gas. The average capacity of the large open-hearth furnaces in foundries devoted entirely to the manufacture of heavy steel castings appeared to be about 50 tons maximum, whereas in this country, in steel works making both steel castings and ingots, the larger furnaces were usually of 60 tons capacity. The most common size of acid electric furnace was about 6 tons capacity.

Manganese, vanadium, and nickel were common alloying agents for the so-called high-tensile steels in America; the use of titanium and other methods for controlling grain size was developing in America. He did not agree with those in this country who believed that in order to defeat the rivals of steel castings the existing standard specifications for steel castings should be stiffened, but he suggested that the problem might be solved by introducing further specifications for high-tensile steel castings similar to the latest specification for railway castings issued by the Association of American Railroads, which originally had a grade "A" for un-annealed castings, and a grade "B" for annealed castings giving 16 tons per square inch yield. Grade "B" had been improved slightly by specifying a yield of 17 tons per square inch and an ultimate tensile strength of 31 tons per square inch, and a new grade "C" had been intro-

duced for high-tensile steel with a yield of 24·5 tons per square inch and ultimate tensile strength of 40 tons per square inch, with a minimum elongation of 22 per cent. and reduction in area of 40 per cent.

In a reference to heat treatment methods, he said that at least two American foundries had introduced differential hardening of different parts of small castings, to obtain improved wear resistance.

Problems in connection with the cleaning and fettling of castings, labour conditions, and foundry research were discussed briefly in the paper.

Aluminium Alloys.

Two papers from abroad, dealing with aluminium alloys, were presented at a session on non-ferrous problems. The system of exchanging papers with foundrymen's organisations abroad started in 1921, when papers were exchanged with America, and the system has since spread throughout almost all the industrial countries of the world.

The first of the two aluminium papers was by Monsieur Gaston G. Gauthier, head of the research department, Compagnie Alais, Froges et Camargue, Chambery (Savoy), and was presented on behalf of the Association Technique de Fonderie (France). It dealt with heat-treatable aluminium-silicon casting alloys and described researches on such alloys containing additions of magnesium, manganese or cobalt. Investigations were made on sand-cast and chill-cast specimens, but the results given were those obtained on sand-cast specimens. The variations of the mechanical properties under the influence of heat treatments and of variations in the contents of Si, Fe, Mg, Mn, Co, and Na were given in detail in tables.

The heat-treatable aluminium-silicon casting alloys, said the author, represented a considerable advance over ordinary silicon alloys. The latter had a tensile strength of 18 kilos. to 20 kilos. per square millimetre, elongation 7 to 10 per cent., hardness 55 to 60 Brinell, and fatigue strength 4·5 kilos. per square millimetre, whereas the alloys containing additions of magnesium and manganese or cobalt had a tensile strength of 27 kilos. to 30 kilos. per square millimetre, elongation 1 to 4 per cent., hardness 90 to 110 Brinell, and fatigue strength 7·5 kilos. per square millimetre.

In addition to their high mechanical properties, those alloys possessed casting qualities almost equal to those of ordinary Al-Si alloys—an extremely important point. It was true that those properties were surpassed by certain alloys containing copper and titanium, but the author was hopeful that further research would lead to improved results and that industry would hear more of the Al-Si alloys with hardening additions.

The second of the two aluminium papers was concerned with aluminium casting alloys, the author being Herr G. Gurtler, Dipl.-Ing., Scientific Officer to the metal laboratory of the Metallgesellschaft A.G., Frankfurt-on-Main, Germany. The paper was presented on behalf of the Technischer Hauptausschuss für Giessereiwesen, Düsseldorf. The author remarked that in England, Germany, and other countries three very similar main types of aluminium casting alloys were in use. They were the alloys having additions of principally Cu, Si, or Mg. According to the demands they had to meet, the alloys also contained further additions of a second of the elements mentioned and/or Zn, Ni, Fe, Mn, Ti, &c. In England, alloys on an Al-Cu basis with additions of Ni and Mg, of the type "Y" and "RR" alloys, were largely employed for high-grade castings, whereas in Germany greater importance had been placed on developing the Al-Si alloys, which possessed good casting properties, were rendered age-hardenable by an addition of Mg, and were valuable constructional materials. Those alloys, together with the Al-Mg group with various additions of Si and Mg, had the further advantage that their resistance to corrosion was far superior to that of alloys containing copper. In addition to those three main groups, there were special alloys, and the author endeavoured to deal mainly with the alloys which are not so well known in England.

He discussed various problems relating to foundry practice and metallurgy recently studied in Germany. One of them was the problem of the removal of gases from the melt, which, he said, was best effected by a combination of salt treatment and standing in a neutral atmosphere. Absorption of gases from the mould could be reduced by lowering the pouring temperature, shortening the period of flow, and increasing the rate of cooling.

The influence of Ti on the fatigue strength of Alpax (which latter was referred to in the discussion as being known in this country as "L33") with various Si contents was discussed in the paper, as well as the influence of various heat treatments. In that and certain other alloys the increased solubility of Mg_2Si at high temperatures was utilised for improving the mechanical properties in heat treatment. The same property, said the author, was possessed by the compound $MgZn_2$, contained in the artificially age-hardenable alloys of the "G54" group, distinguished for their excellent suitability for anodic oxidation.

He commented that the results of the investigations presented by Monsieur Gauthier corresponded with those obtained in the metallurgical laboratory of the Metallgesellschaft A.G.

Chemical Changes of Cast Iron in Cupola Melting.

A further paper from abroad was contributed by Dr. J. T. Mackenzie, of the American Cast Iron Pipe Company, of Birmingham, Ala., U.S.A., presented on behalf of the American Foundrymen's Association. The author has already published the results of a large number of researches on various aspects of cupola operation—the influence of coke size, of blast pressure, and of different types of cokes on melting—carried out as scientific research, but in actual foundry cupolas of commercial sizes, and the present paper was a concise summary of those various results. Matters such as the effect, on the melting and on the properties of the iron, of tuyere height, carbon loss and carbon pick-up, of the carbon and sulphur in the coke, and so on, were also discussed, and the author gave a warning against arguing from one law of physics or chemistry to the exclusion of others in connection with cupola operation. He referred to the many compensating reactions taking place in the cupola, and suggested that it was because of those complexities that cupolas had been run so successfully on an empirical basis for so many years.

Copper in Cast Iron.

The results of experimental work at the British Cast Iron Research Association on the influence of copper in cast iron were recorded in a paper by Mr. A. J. Nicol Smith, which we propose to reproduce later. When the investigation was initiated the literature on the subject was in a very confused and contradictory condition, although it was generally agreed that additions of copper increased the hardness and strength and the corrosion resistance of cast iron. It was thought that most of the confusion in the literature arose because most investigators had experimented with only a limited copper addition, and often only on one base iron. Therefore it was decided to deal first with the addition of relatively widely spaced additions of copper to a series of base irons covering a wide range of composition, previous experience having shown the difficulties of drawing accurate metallurgical conclusions from experiments on a limited range of compositions. The second part of the investigation dealt in greater detail with the influence of smaller quantities of copper on a more limited range of base materials, covering approximately the engineering irons of the present day.

The Modern Manufacture of Machine Tool Castings.

Mr. J. Blakiston (of Modern Foundries, Ltd., Halifax) surveyed present-day practice and developments in the production of machineable grey iron castings for machine tools. Cast iron, he said, possessed many definite advantages, which made it an ideal material for use in the construction of machine tools, and precluded the likelihood of its being superseded by any other material, provided full advantage was taken of developments which were constantly taking place in its manipulation. Outstanding properites of cast iron which commended it to the machine tool manufacturers were ease of casting to any desired shape, low production cost (the cost of the castings, even when in alloy iron, was rarely more than 20 per cent. of the cost of the finished machine), its rigidity, capacity for absorbing vibration, and low coefficient of friction. It was one of the few materials which formed a good bearing with itself in its natural or untreated form.

He divided cast iron as used in machine tool construction into three grades: (1) general engineering cast iron (straight pig and scrap mixture), giving 1·0 per cent. phosphorus); (2) high-duty steel or refined iron mixture (medium phosphorus); and (3) low total carbon alloy cast iron. He gave some typical compositions, and discussed their various properties, and went on to deal with factors in melting practice, moulding methods, refractory materials, and the methods of production of typical machine tool castings. To the designer of castings to be manufactured from high-tensile cast iron he said it was imperative that an even section be maintained throughout and that no hot spots were created through the junction of too many ribs at one point. A transverse rib should be broken where it entered a right-angled corner by means of a small round core. A casting was not always strengthened, he said, by thickening certain sections, for a reduction of tensile strength might result from "mass effect."

The draughtsman should visualise the moulder's parting line and incorporate in his design the necessary taper for stripping. That would reduce moulding costs and would do much to eliminate misshapen castings caused through excessive rapping or uncontrolled pattern taper applied by the pattern-maker.

Finally he emphasised that machine tool moulding required constant personal supervision to detail and probably had done much to enable the small jobbing foundry to survive intensive competition on account of its working owner always being on the spot with a practical knowledge of the class of machine tool casting on which he had specialised.

Sand Blasting for Vitreous Enamelling.

Mr. H. Whitaker, of the Rustless Iron Company, Ltd., Keighley, presented on behalf of the Institute of Vitreous Enamellers a paper on sand blasting as applied to the vitreous enamelling process. He dealt with many aspects of the problem. In a reference to air pressure he said that difference of opinion still existed as to the best pressure for sand blasting metal for vitreous enamelling, but 50–55 lb. per square inch at the nozzle appeared to be generally used in this country, although it might rise to 70–80 lb. or fall as low as 30–35 lb. Probably the last range was the absolute minimum for giving a satisfactory bond for the enamel, and the higher pressures were used to obtain a greater output. It should be borne in mind, however, that the power required to compress air increased rapidly with the pressure; for example, to produce 100 cubic feet of free air per minute at 30 lb. pressure, 12 H.P. were required; whilst for the same amount at 60 lb. pressure, 18 H.P. were required. Few users of compressed air had an accurate idea of its cost. It had been estimated that a plant with three ¼in. nozzles cost about 2s. 6d. per hour for compressed air, or over £300 a year.

Letters to the Editor.

We do not hold ourselves responsible for the opinions of our correspondents.)

SELECTION OF A PROFESSION.

SIR,—It is generally admitted that the standard of technical education has greatly improved in the past decade, and it is now possible for young men in comparatively straitened financial circumstances to obtain education equal to that of their more fortunate brethren. There is, however, one serious omission in the education of all young men who are proposing to take up the profession or business of engineering.

Recently in my official capacity I have had to interview a number of young men from the various universities and colleges, and the lamentable lack of knowledge of the various branches of the craft gives me the impression that whilst the younger generation are being taught the very necessary theoretical side of their business, no proper provision is made to inform them of the openings for which they might be suitable. On questioning these young men as to their interests—*i.e.*, whether they wish to go in for the administrative side, production departments, sales division, or technical department—the majority have no idea, and almost without exception the answer is, "I do not know enough about that to say. What do you think?" This, in my opinion, is a very serious state of affairs, and I consider it would be well for our various educational authorities to make some effort to instruct students in this very vital matter.

It is obvious that whilst one student might make a good designer, and plan his career with that in mind, another might be eminently suitable for the production side of engineering, and naturally his training would be very different from that of the first student. If these young people do not know the facts, they are not going to obtain the best from their educational period. For a youth of twenty-one or twenty-two to leave a university or engineering college with a degree, but with no idea either as to what he wants to be, or in many cases what he can be, is a hopeless state of affairs.

In these works we endeavour, first, to find out the ideas of the candidate for training on his future career, and, secondly, to guide him in the proper path to achieve that end. Furthermore, during training some young men change their ideas, because they know there are these various channels open to them, and having this knowledge can equip themselves for a happy and useful career, whereas if they do not know it is conceivable that they might go on working in an uncongenial job which does not make for success.

That some of our public schools have "careers" masters is known to me, and I realise that they perform a very useful function, but even in those cases not much help is given because the "careers" masters themselves are not aware of the posts available.

The old days of an engineer being just an engineer are over. The day of specialisation is here, and there are as many kinds of engineer as there are doctors, if not more.

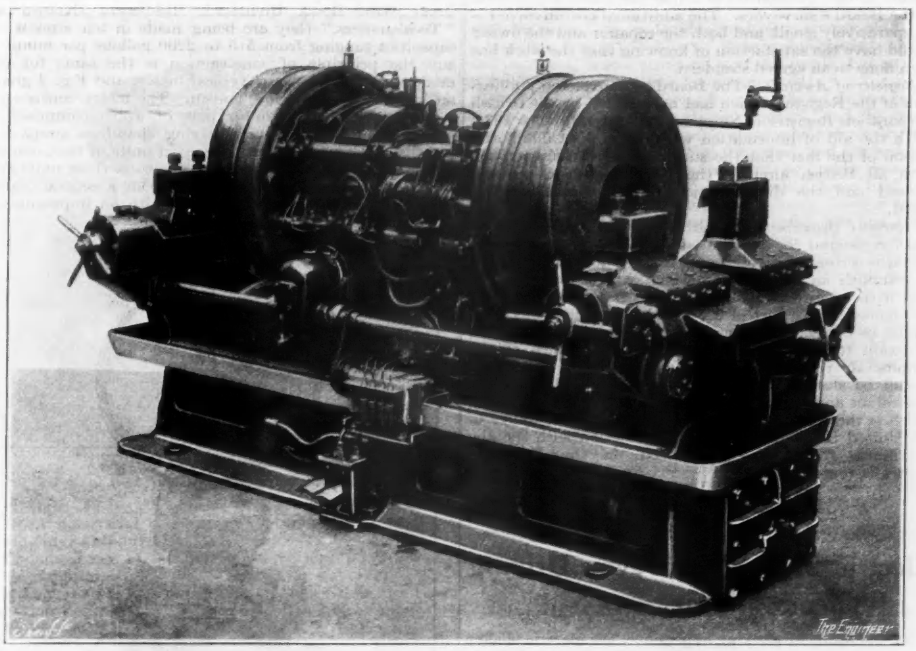
It is hoped that this letter will come to the notice of interested parties, and that it may possibly cause some steps to be taken to rectify the very serious omission in the curriculum of the places where engineering is taught.

RUSTON-BUCYRUS, Ltd.,
R. J. REES ARMISTEAD,
Apprentice Supervisor.

Lincoln, June 14th.

SLUDGE PIPES.—A report has been issued on the explosion of a cast iron sludge pipe at Middlesbrough. The explosion was attributed to general wastage of the cast iron pipe by external corrosion. There was indication that the pipe had not been uniform in thickness; this in itself was not serious until general wastage occurred and the pipe so reduced in thickness that it was unable to withstand the pressure when the sludge valve on the boiler was opened. In his observations, the Engineer Surveyor-in-Chief of the Board of Trade states: "Sludge pipes being open-ended, it is not always realised that a considerable pressure may accumulate in them during the process of blowing down the boilers to which they are attached. The pipes are very liable to corrosion, and as they are frequently placed at ground level in positions where workmen are employed they should be periodically examined with the same care as boilers."

TUBE AND BAR CUTTING-OFF LATHE



A New Cutting-Off Lathe.

THE hollow-spindle cutting-off lathe shown in the accompanying illustrations has been developed by Brookes (Oldbury), Ltd., Birmingham, for the handling of heavy tubes and bars. This machine has a hollow spindle 9¼in. diameter, and is capable of taking tubes up to 9¼in. outside diameter. In operation uncut tubes are inserted at the left end of the spindle; one end is cut by the right tool; the tube is then traversed further through the spindle; its other end cut by the left tool, and the finished tube is withdrawn and deposited at the right of the machine. This method of handling tubes saves time and also the extra space required for turning the tube round when using a machine fitted with a chuck and tool rest at one end only.

The chucks are of the company's self-centring, quick-grip type, each having eight jaws to grip tubes from 9¼in. to 7in. diameter, and a spare set of jaws for tubes from 7in. to 4½in. diameter. Each chuck is totally enclosed to prevent the ingress of dirt or swarf, and the jaws have smooth flat faces, as the grip is of sufficient power to hold without the use of grooved jaw faces. The opening and closing of the chucks is done by sliding back plates coupled on telescopic rods. This method of operation confines the end thrust within the spindle and resulting stresses are not transmitted to the main bearings or body of the machine.

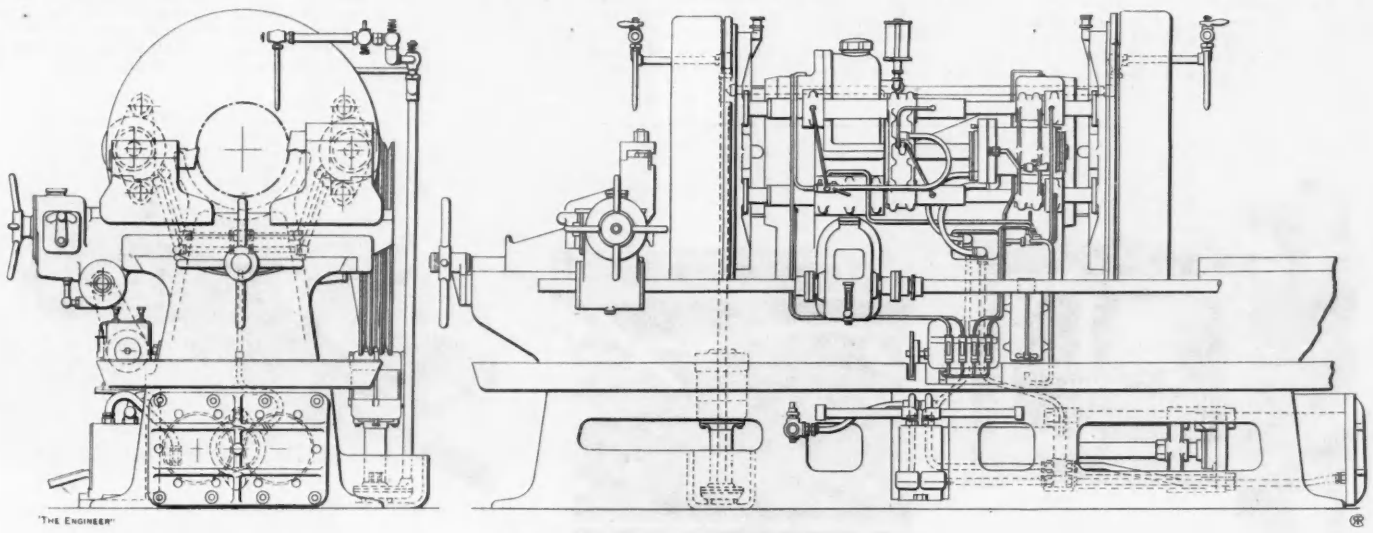
The chucks can be operated with the spindle stationary or rotating by means of oil hydraulic cylinders at the rear and front of the machine, the cylinder bodies sliding to operate one chuck and the pistons operating the other chuck. The telescopic operating bars are rigidly mounted to ensure parallel motion of chuck back plates.

Power for operating the chucks, which is taken from air mains at 80 lb. per square inch, is controlled by a double non-locking foot valve at the front of the machine, working two parallel cylinders which, in turn, operate directly on a single hydraulic cylinder. These air cylinders and the primary hydraulic cylinder are built in one unit mounted in the base casting of the machine. Hydraulic power is transmitted from the primary cylinder to the chuck-operating cylinders through flexible metallic tubes. Means are provided for balancing the oil supply and also for replenishment automatically, should any loss occur through leakage, from a reserve cylinder of glass mounted over the machine centre.

The double tool rests at each end of the machine are strongly built, and, in addition to hand control wheels, are provided with automatic feeds for parting off. Tool feed control is by means of short rocking levers at the outer side of the tool rest gear-boxes. A worm wheel of phosphor-bronze mounted on the main spindle drives the machine. This worm wheel is geared to a pulley at the side of the machine, which is coupled by vee belts to the electric motor of the unit. The worm wheel is totally enclosed and runs in an oil bath. Varying speeds are obtained by utilising a change-pole type of three-speed A.C. motor.

A one-shot system of lubrication is arranged for all bearings of the chuck-operating system, and adequate lubricating arrangements are made for all other wearing parts. A slurry pumping system is provided, the reserve tank being in the machine base and coolant is distributed by means of a self-contained motor-driven vane pump fitted in the tank rear extension.

We are informed that on test with the spindle running at 35 r.p.m. a tube of high-tensile steel, 60 tons per square inch tensile, 7·9in. outside diameter by 0·205in. thick, has been parted off clean in twenty-seven seconds.



GENERAL ARRANGEMENT OF CUTTING-OFF LATHE

Aircraft Registration.

RECENTLY the control of the registration of British civil aircraft has been delegated to the Air Registration Board. The main portions of the chairman's report of the Board for the year ended March 31st, 1938, is reprinted below.

Although incorporated as a Board in February, 1937, operations were actually started on April 1st of that year, when the Board took over from the Joint Aviation Advisory Committee of the Shipping Registers the work of recommending the renewal of certificates of airworthiness of certain classes of aircraft.

The majority of the staff employed by the Joint Aviation Advisory Committee were taken over by the Board as from April 1st, and further appointments were made as from that date in order that the first stage of delegation of responsibility from the Air Ministry might be satisfactorily dealt with. This delegation was communicated to the Board on March 30th, 1937, and consisted of the duty of recommending the renewals of certificates of airworthiness of privately owned, club, charter, and aerial work aircraft. The delegation was in the nature of consolidation and extension of the work done by the Joint Committee.

By July 28th, 1937, the increase in the Board's survey staff and the establishment of district offices warranted the acceptance of the further responsibility entailed in the recommendation of renewal of certificates of airworthiness of all British civil aircraft.

It was clearly desirable that concurrently with this additional transfer of work, which included "hire and reward" aircraft, the Board should accept responsibility for the supervision of ground engineers, who are so closely associated with the maintenance of airworthiness of these aircraft. On September 6th, 1937, the Secretary of State for Air delegated to the Board the work of examination of ground engineers and the recommendation of the issue of licences. From this date also the recommendation for renewals and extensions of ground engineers' licences was transferred so that by the end of 1937 the Board were virtually responsible for the whole system of maintenance of airworthiness.

On January 17th of this year a further stage in the transfer of duties from the Air Ministry to the Board was taken, when the work of recommending the issue of certificates of airworthiness of "subsequent" aircraft, constructed by approved firms, was delegated to the Board. Responsibility for the approval of firms' inspection was transferred to the Board on the same date, but it will be some time before the work involved in the transfer of these duties is complete.

At this stage the work of the Board consisted in making recommendations to the Secretary of State for Air on the basis of existing regulations, but they had no authority to advise him that any of these should be modified. On February 15th, 1938, the responsibility for advising him in connection with the functions already delegated to the Board gave them the necessary powers to recommend the modification of existing requirements.

Consideration of this brief outline of the Board's work during the first year will show that it could scarcely have been accomplished without the co-operation of the officers of the Air Ministry. Sir Francis Shelmerdine, Colonel Outram and their staffs have given the Board every possible assistance, and have greatly facilitated the transfer of responsibility from the Ministry to the Board.

Certificates of Airworthiness.—During the year under review 2660 surveys have been carried out, as a result of which 987 recommendations for renewal of certificates have been made. Of these, 93 were in respect of "hire and reward" aircraft, and 894 of aircraft in the privately owned, club, charter, or aerial work categories.

These figures do not represent the total number of British certificates of airworthiness renewed during the period, as the responsibility for "hire and reward" aircraft was not accepted by the Board until August, 1937. The figure of 894 given for other classes does, however, mean that approximately this number on the British register have valid certificates of airworthiness. The approximation arises from the fact that at a given moment a certain number of aircraft are undergoing overhaul, prior to renewal of certificate of airworthiness.

To deal efficiently with the distribution of work, the Board have established offices at Glasgow, Liverpool, Hatfield, Heston, Croydon, and Southampton, with sub-offices at Hythe and Hamble. At present it is doubtful if there is sufficient work all the year round to keep the Northern and Scottish surveyors fully occupied, but the additional convenience to operators justifies the expense involved.

The fact that aircraft suffer a gradual increase in tare weight makes it necessary that they should be reweighed at regular intervals, usually when the aircraft undergoes overhaul for renewal of certificates of airworthiness. It is hoped that in time more facilities for weighing may be available, especially at municipal aerodromes, where permanent weighbridges might well be regarded as part of the normal equipment. In the meantime the Board

have decided to meet the operators' convenience so far as they are able, and have stationed cars, carrying portable scales specially constructed for weighing aircraft, at Glasgow, Liverpool, Hatfield, and Croydon. These scales are only a substitute for the weighbridge, as they cannot be expected to have the same degree of accuracy, and cannot be used to weigh aircraft of more than about 10,000 lb. tare weight. The Board would remind operators that in offering them the use of these scales, they are not accepting the responsibility for providing the means of weighing aircraft. The onus of showing that the weight has not increased remains with operators and owners. When the scales have to be transported long distances the Board offer their use subject to the payment of cost of transport by the aircraft owner.

Ground Engineers.—The Board are concerned in the maintenance of airworthiness by reason of the responsibilities which they have accepted for the licensing and supervision of ground engineers.

Since the examinations on which the recommendations for the issue of licences are based were carried out by the Board, eighty examination boards have been held, involving the examination of 366 candidates. As a result of these examinations, 275 new licences have been issued; and 418 variations and extensions of licences have been recommended after a modified examination. Renewals of licences recommended have numbered 701, based on reports on individual ground engineers furnished by the Board's surveyors.

The maintenance of a high standard of competence of the men so largely responsible for the continued airworthiness of aircraft is a matter of very great importance, and the Board have given it their constant attention. It may be that the present system is capable of some improvement, but how it can be done is not immediately apparent. Any examination of the kind now carried out tends to become stereotyped, and well-prepared candidates have little difficulty in becoming word perfect in the published syllabus, but this achievement does not indicate their ability to do the actual work. Much of the examination must therefore be directed to this latter vital qualification. It is within the powers of the Board to modify the present system, but they do not feel that they have yet had sufficient experience of it to express an opinion of the extent to which it might be revised with advantage.

Inspection of Aircraft During Construction.—The duty of recommending the issue of a certificate of airworthiness to a "subsequent" aircraft—that is, one which is similar in all respects to a prototype which has a certificate of airworthiness—has recently been delegated to the Board. Up to April 1st, 1938, seven of these recommendations had been made.

Approval of Firms' Inspection.—A recommendation by the Board for the issue of a certificate of airworthiness for a "subsequent" aircraft may be made on the report of a constructing firm, if that firm be approved for the purpose. It follows that approval of firms' inspection is bound up with the responsibility which the Board have accepted in connection with the issue of the certificates, and approval of firms' inspection is now being given by the Board.

The intention of the Gorell report was that gradually increasing reliance should be placed on firms producing civil aircraft and the materials used in their construction, and the Board have decided to frame their regulations so that this intention can be fulfilled as experience warrants. In the past all material to be used by the aircraft constructor has had to be accompanied by evidence that it has been manufactured under the supervision of approved inspection staffs. The Board's intention is to allow constructing firms to make application for an approval which enables them to satisfy the Board that the material used is in accordance with the requirements.

It is felt that the present procedure under which any firm can apply for approval to supply material to an aircraft constructing firm is likely to involve the Board in more expense in giving and maintaining such approval than is warranted by the benefits which accrue to the aircraft constructor or operator. Many approvals of this type have been obtained by firms which have never supplied material for civil aircraft. The system has had the effect of making aircraft material costly as compared with material of similar quality used in other industries, and it appears worth while to provide an alternative which is based on well-established practice and can ensure an equal degree of safety.

It is important that an aircraft should be repaired to similar standards of workmanship to that to which it was built, and the responsibility for this is placed on an "approved" repairing firm or on a suitably licensed ground engineer.

Some difficulty arises in maintaining a standard of workmanship as between firms which are in competition and which may be depending entirely on aircraft repairs for their livelihood. The Board make periodical visits of inspection to repairing firms, but it would seem worth while for the aircraft owner to require more often that large repairs should be carried out under the direct supervision of the Board's surveyors. The additional cost involved is comparatively small, and both the repairer and the owner would have the satisfaction of knowing that the work has been done to an agreed standard.

Register of Aircraft.—The Board took over the publication of the Register, which had been issued by the British Corporation Register of Shipping and Aircraft since 1932. With the aid of information which is now available, by reason of the fact that the survey staff is in close touch with all British aircraft, the Register is continuously revised and the dissemination of information accelerated.

Overseas Organisation.—Although the number of aircraft registered in the United Kingdom and operating overseas is comparatively small, it is the duty of the Board to establish an organisation which will enable them to deal with an aircraft holding a British certificate of airworthiness in any part of the world. Although this ideal cannot be realised for some time to come, it is the Board's intention to keep it in view. The importance of the Empire air routes required that officers of the Board should be stationed at Alexandria (the junction of the Australian and South African routes), and at Singapore, which is the furthest point to which the responsibility of the United Kingdom extends in connection with the airworthiness of flying boats used on the England-Australia route.

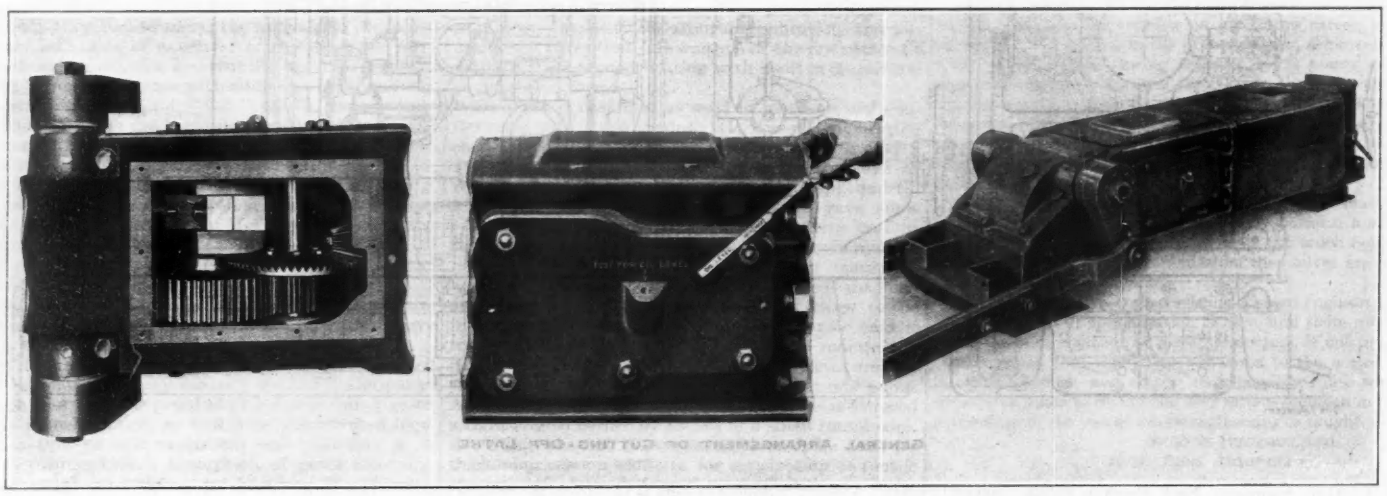
Electric Shaker Conveyor Driving Gear.

As the result of working experience, the electric shaker conveyor driving gear manufactured by British Jeffrey-Diamond, Ltd., of Wakefield, has recently been modified. While no radical changes have been made in the design as developed for collieries many years ago, the modifications that have been introduced make the machine suitable for the more exacting duties that are demanded of all types of underground conveyors. The tendency to work longer faces and handle larger tonnages per shift has had to be faced, but the fact that little alteration has found to be necessary in the original design is considered to be proof that the makers of the machine have been working on the correct lines.

The main principle remains the same, a smooth effective jigging motion being obtained without vicious kicks, which give rise to high cost in troughing maintenance. The gearcase (Fig. 1) and switch of the new equipment are in a steel case having great strength and offering resistance to ill-usage. On either side of the gearcase is a receptacle for a dipstick (Fig. 2) for testing the oil level, and the stick is marked for maximum and minimum levels, as shown in Fig. 2. As lubrication of the bearings is now provided by direct splash from the gear, grease nipples on the first and second shafts have been eliminated. Bearings with housing open on the inside have been provided for this purpose and to facilitate easy removal.

As the rocking lever shaft is too far from the gear wheels to be effectively lubricated by splash, an oil pump is fitted to ensure definite lubrication, and while this is not a new feature, drain holes are now provided to remove all surplus oil, whilst ducts lead it back to the sump instead of permitting this oil to find its way to the outside of the gearcase.

The connecting-rod cap and bolts have been increased in size and improved in construction to withstand the heavier shocks and stresses resulting from the more exacting requirements. An improved form of tooth on the spur gears of the second reduction gives smooth meshing between the teeth. Four extra large holes in the gearcase hold the stilling feet in position, and screws of high-tensile steel have increased the aggregate strength by over 300 per cent. A strainer in the oil filling plug can be easily removed for cleaning and a separate small plug gives visual indication when the correct oil level is reached. These improvements in detail result in greater mechanical strength, smoother operation, steadier running, and reduced maintenance charges. A general view of the improved electric shaker conveyor driving gear is given in Fig. 3.



FIGS. 1, 2 AND 3—ELECTRIC SHAKER CONVEYOR DRIVING GEAR: GEARCASE, DIPSTICK AND GENERAL VIEW

A New Fluid Meter.

A NEW range of fluid meters of the positive displacement type has recently been introduced by Tecalemit, Ltd., Great West Road, Brentford, Middlesex. Known as "Tecalemeters," they are being made in ten sizes with capacities ranging from 5·5 to 2200 gallons per minute, and the principle of construction is the same for all models. Fig. 1 shows a typical meter, and Fig. 2 gives an impression of the mechanism. The meter consists of a built-up body, the lower part of which comprises a crank chamber and four metering chambers swept by pistons. The pistons are built up in units of two, one at either end of a connecting-rod, and two of these units are mounted as a cruciform assembly about a central crank shaft. Each piston head is fitted with an impregnated

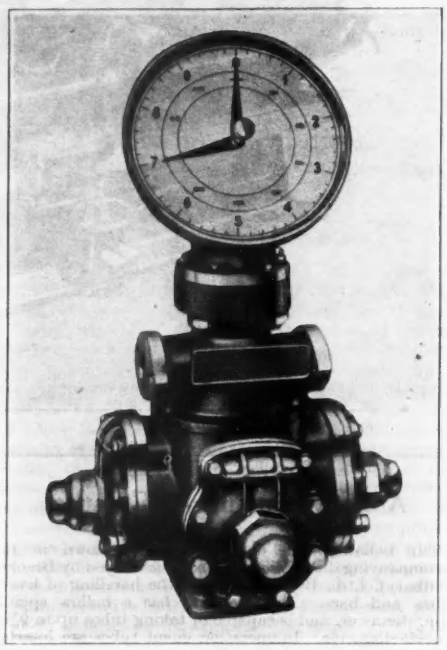


FIG. 1—"TECALEMETER" FLUID METER

leather cup-shaped seal, which is reinforced by a spring steel backing to ensure fluid tightness.

The crank shaft is keyed at its top to a rotating disc valve, which divides the upper part of the body into two chambers, one being for the inlet and the other for the delivery of fluid. This valve distributes the fluid to and releases it from each cylinder in succession. Its general shape is that of a hollow truncated cone, with a centrally disposed partition. Two ports on the bottom face communicate each with further apertures in the conical skirt and flat top of the valve. The skirt ports are the inlet ports, and the top ports the outlet ports. The valve is set to give continuous motoring to the spindle and full volumetric effect in the meter spaces. It is of patented construction, and is claimed to secure particularly favourable conditions of hydraulic balance. It is further claimed that it makes an important contribution to the smooth running and accurate metering of the instrument. A spring-loaded bellows type seal ensures the liquid tightness of the distributing valve.

Referring to Fig. 2, the fluid inlet of the meter is on the left-hand side, and the outlet on the right. It should be pointed out that this illustration is not strictly correct, as the two ports should be diametrically opposite. The liquid under pressure flows into the lower header chamber and down through the skirt and slot in the base of the distributing valve to each metering chamber in succession as the valve rotates. As one piston is moved by the fluid, the motion is transmitted by the connecting-rod to the opposite piston, which forces its contents through the slots in the base and top of the valve into the upper

header or outlet chamber. The progressive movement of the pistons turns the distributing valve and brings each cylinder into successive communication with the inlet and outlet liquid ports.

The counter mechanism, which is directly connected to the crankshaft, can be supplied with either a vertical dial with two hands and cyclometer type total integrator,

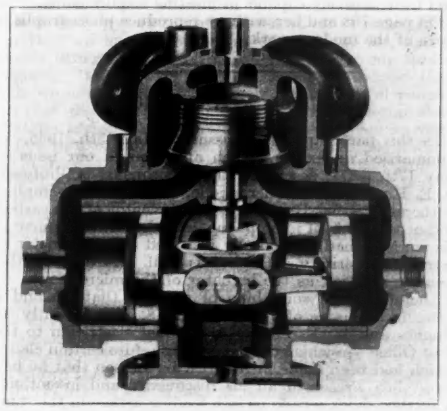


FIG. 2—ARRANGEMENT OF METER

or with horizontal cyclometer integrator showing total throughput and a trip counter.

The crankcase of the meter is filled with oil to ensure the minimum wear of moving parts and reduce any frictional resistance. For use with these meters the company has developed a range of air and water eliminators, and a pre-set mechanism for automatically closing an inlet valve after a required amount of fluid has passed through the meter.

Construction of a Duct Line beneath Caldon Canal.

RECENTLY the engineers of Callender's Cable and Construction Company, Ltd., carried out an interesting work in the construction of a duct line under Caldon Canal, for the North-West Midlands Joint Electricity Authority, Stoke-on-Trent. The operations are illustrated by accompanying engravings. The bridge carrying cables across the canal from Stoke-on-Trent generating station to Litchfield Street was in a dangerous condition, owing to corrosion, movement in abutments, and heavy loading. Any scheme for having the old bridge replaced could not be entertained, as the approaches limited further development, and, as risk from aircraft attack had to be considered, a bridge would be vulnerable; hence the decision to construct a duct line below the bed of the canal. Consideration had to be given to the fact that the whole area was liable to subsidence from mine working and geological faults, especially near the canal, and that at the point of the proposed duct line the east bank of the canal was on an embankment and the cooling towers on the west side were within 17ft. of the retaining wall and 7ft. above water level. The stratum below the canal bed is clay, peacock marl, shale, and coal, dipping towards the west at 14 deg. One coal seam, 3ft. 6in., outcropped on the east side of the bed. Actually it was discovered that there were two seams of coal which diverged at different angles and levels.

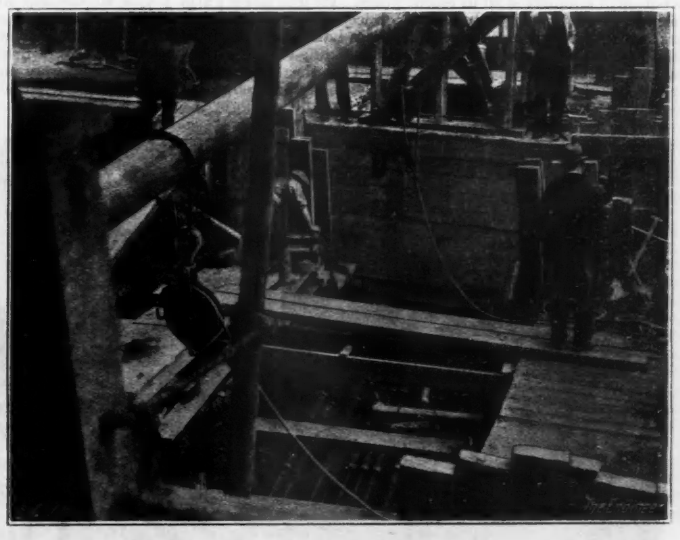
It was necessary to dam and drain the canal, excavate the bed and construct the duct line of fifty-one 4in. and twelve 5in. ducts, with two 6in. cast iron water pipes, at a depth to give 2ft. minimum cover below the bed of the canal, together with the necessary concrete manholes, approach ramps, ventilation shaft, &c., and at the same time conform to the canal company's stipulation that the preliminary works must not interfere with normal canal traffic and that a certain clear waterway must be maintained.

It was arranged to drain the canal for three days for the major part of the work. It was decided to complete the retaining walls, leaving an opening for the duct line, in the preliminary work, and also the formation of manholes. Owing to the nature of the stratum, steel sheet piling could not be used on the cofferdams necessary for the construction of the retaining walls, and these were formed of a double sheet piling of elm, with a 2ft. 6in. puddle clay wall between. Some trouble was experienced with the cofferdams, owing to "blows" from water-bearing strata, and continual water pumping was inevitable, but in due course the retaining walls were concreted.

Two nights later stop planks were placed in the canal about a quarter of a mile above the work, and the canal was gradually drained, an operation which took several hours. Some water was left in the canal, and the leakage through the stop planks was dealt with by puddle dams on each side of the excavation and a timber flume bridging the cut. As soon as the stop planks were fixed, a start was made with the excavation on the canal bed and towpath, and with the placing of gangways. By 5 p.m. of the same day on which the draining operation had finished, the excavation was to formation level and the 2in. rough concrete mat laid. The cast iron pipes were laid and jointed by midnight, and by 7 p.m. of the next day the ducts were laid across the canal and concreted in, Ciment Fondu being used. The remainder of the three days period was occupied in puddling the canal bottom above the duct line, and cutting back 10ft. on either side to a depth of from 1ft. to 3ft., and repuddling the canal over this area.

The volume of excavation, concrete placed, and ducts laid during the three-days period were as follows:—Excavation, 125 cubic yards, of which about 25 tons was shale and coal; concrete, 41 cubic yards; puddle clay, 74 cubic yards; and ducts of 4in. and 5in., 14 tons.

WEST RETAINING WALL



EAST RETAINING WALL AND DUCT LINE

Engineering Notes from China.

(By our own Correspondent.)

HONG KONG, May 2nd, 1938.

The War and River Conservancy.

THERE is anxiety in marine circles in the Far East concerning the condition of the channel from the Pacific to the Port of Shanghai, because, for eight months during the hostilities in China, no dredging or conservancy work has been done by the Whangpoo Conservancy Board and the channel is silting up. Every shipping company using the Port of Shanghai realises the danger for heavy draught vessels that steam up and down the river, over the Woosung Bar and the Fairy Flats. After many years of careful work a channel deep enough for large ocean liners was cut through those great masses of silt deposits. Unfortunately, not only has the costly dredging apparatus been in the hands of the Japanese since the outbreak of war, but the invaders have taken no steps to use it. At this time of writing there seems to be no probability that the equipment available for dredging will be returned to the Whangpoo Conservancy Board. Even the sounding instruments are in the hands of the Japanese, so that it is impossible to ascertain what is the precise condition of the channel.

Idle Dredgers.

A Shanghai manager of one of the large shipping companies said that it was very exasperating to have the anxiety and delay caused by the present state of affairs and to look out of his office window to see the largest dredger in Shanghai, and one of the largest dredgers in the world, lying idle in the stream. Already some of the wharves are silting up, causing a distinct shortage in the available berthing accommodation. At the two wharves used by the Asiatic Petroleum Company in Shanghai, not less than 4ft. of silt has been deposited during the last eight months. Private dredging has been carried out by the owners of Holt's Wharf, where the Blue Funnel vessels are berthed; the difficulties of the manager were less than those of others responsible for wharves because Holt's Wharf adjoins the natural bed of the river. A complication, causing considerable damage, is the boom at Nantao. This has caused heavy scouring on the Pootung side of the river, opposite to the International Settlement, but it has also increased the normal silt deposits on the Shanghai side. The ebb tides are scouring out the ground beneath the wharves on the Pootung side, and while, so far, no real damage has been done to those strongly built structures, it is apparent that if precautions are not soon taken very serious damage may take place. The Whangpoo is a swift running river, and even well-designed concrete piles cannot stand up indefinitely against continual scouring.

Methods of Dredging.

The importance of Shanghai to British interests will be realised when it is stated that 18 million tons of shipping entered the port in 1935, and that but for the smuggling of Japanese goods into areas of North China, which they then controlled, the shipping returns for Shanghai would have shown a higher tonnage. Great Britain has very large shipping interests in China, and the British have been mainly responsible for the rapid development of Shanghai. It was due to the initiative of the British that the Whangpoo Conservancy Board, an offshoot of the Chinese Maritime Customs Service, was formed. It is of interest to note that in the Whangpoo there was established a definite practice of using for major work bucket dredgers which discharge into steel mud lighters. The latter were towed to a mud pump. The mud from the river was then liquefied by the injection of as much as eight times its volume of water. A pipe line, 28in. in diameter, was used to carry this mixture into large basins, surrounded by dykes. The mud settled in the basins and the surplus water was drawn off over a weir, returning to the river. It was decided that simple suction would not remove the silt from the river. Pipe line dredgers were also considered unsuitable, as they would have interfered with shipping traffic. Grab dredgers were used for riparian dredging in the Whangpoo because of the traffic. The disadvantages of high costs, irregular cuts, intermittent action, liability to small breakdowns, &c., were fully realised by the engineers concerned with the work; but other considerations favoured their selection. The energy used in the Whangpoo for bucket dredging—dredging to about 40ft. below water level—was about three-quarters of an I.H.P.-hour per cubic yard dumped into the barges. This energy, of course, varied with the material attacked. The hardest material in the Whangpoo is a rather sandy mud, and when that was dredged the energy used rose to as high a figure as over one and a half I.H.P.-hours per cubic yard dumped in the barges.

Light Lorries.

The demand in China for the German 2-ton lorry arises not only because it is so much less in cost, but because the road construction and the numerous boat ferries over creeks and rivers favour the lighter vehicle. As some evidence of the traffic by road under war conditions between Hong Kong and Hankow, it may be mentioned that the British American Tobacco Company transports by lorry almost every day supplies of tobacco leaf for its very big factories in Hankow. The railway between the two cities is so crowded with freight cars that it is said to be impossible to obtain a truck on the line until four months ahead. It is impossible for the makers of C.I. engines to meet the great demand for lorries and buses in China, and in consequence large numbers of Canadian, British, and Canadian petrol vehicles have been imported. The main difficulty at present is to obtain delivery of any type of lorry. This also applies to all British C.I. engines; it is said that it is impossible to obtain deliveries of them under eight months.

It may be mentioned that since the outbreak of war an enormous quantity of railway materials, ordered for the Chinese lines, has been landed in Hong Kong. As many as thirty-three big Skoda locomotives for the Tientsin-Pukow Railway were put ashore in the Colony and have been placed on a siding of the Kowloon-Canton Railway (in British territory) after being tried out on the British section of the line. There are also luxurious wagon-lits carriages, ordered for North China railways, on the sidings in Hong Kong. Enormous stores of petrol and war material are piled up awaiting transport inland. It is a curious fact that, in spite of the Tokyo-Berlin-Rome triangle, Germany and Italy have been active in supplying China with the sinews of war.

Centenary of George Kent, Ltd.

THIS month the firm of George Kent, Ltd., of Luton, celebrates its centenary, and last Friday, June 17th, a party visited the works as its guests to luncheon. As a matter of fact, it is a little difficult to fix the date of the founding of the firm. For a hundred years it has been under the control of only two men, George Kent, the founder, and his son Sir Walter Kent, the present chairman. George Kent was born as far back as 1806, and he had memories of the Napoleonic era and of the fears that dictator raised in this country. In 1834 or thereabouts he started a business in George-street, Euston-road, as a blindmaker, but the date is rejected as that of foundation, and the later one, 1838, approved, as at about that time the manufacture of domestic labour-saving devices, the mainstay of the firm for the rest of the century, was taken up. George Kent's name is best remembered in connection with the knife-cleaning machine which he invented, and which was only rendered obsolete by the invention of stainless steel in recent years. He also introduced a domestic refrigerator, in which ice was used, and chartered ships to bring cargoes of ice from Lake Wenham in Norway to England. The success of the knife-cleaning machine enabled premises to be opened in the Strand for the sale of the various domestic articles manufactured, while the factory and wholesale department was at 199, High Holborn.

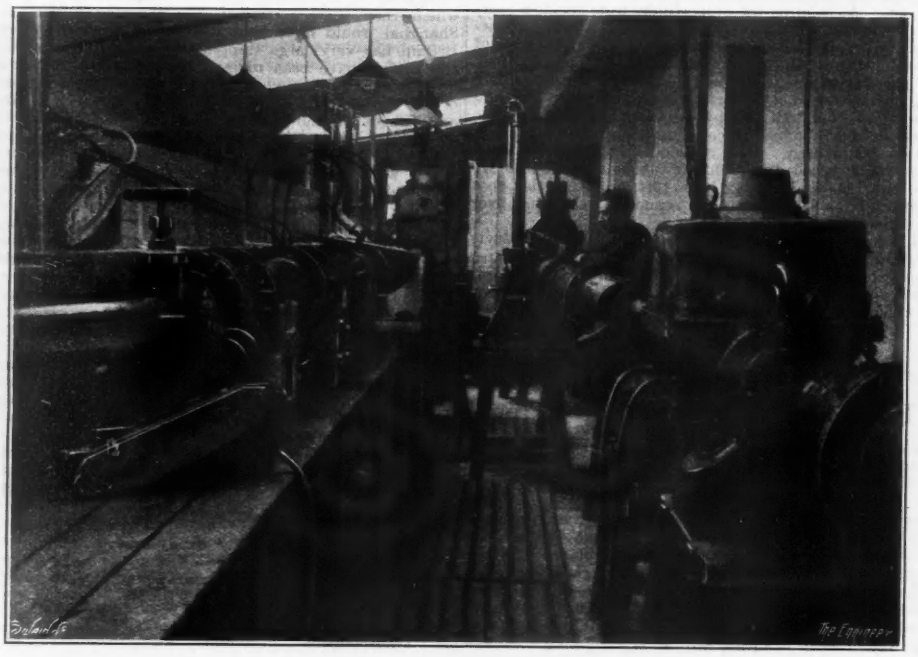
It was not until 1883 that the firm first began to take any interest in the various measuring meters with which its name is now so closely connected. The change occurred owing to the interest of Mr. J. W. Sutton, who joined the firm in 1867, in matters affecting ratepayers. In 1881 the right of the New River Company to levy a water rate upon the rental value instead of the rateable value, which was taken to be the rental value less one-sixth for repairs, &c., was contested by a certain Archibald Dobbs, a barrister, and fought by all the eight London water companies, which then existed, up to the House of Lords, where the decision was in Dobbs' favour. Mr. Sutton's attention was attracted by the case, and in frequent meetings with Dobbs the want of equity in charging by rate instead of by quantity consumed was discussed. As a result, Mr. Sutton was led to consider the possibility of the manufacture of a water meter. Shortly afterwards the firm took up the agency for the Meinecke inferential meter exhibited at the Inventions Exhibition of 1885, and bought the patent rights in a semi-rotary meter designed by Frank Walker, of Arizona, and shown at the same Exhibition. The Venturi meter was added to the range manufactured in 1893.

It was not, however, until 1910 that any meters for fluids other than water were constructed. But in 1908 the attention of the research department which had been set up in consequence of the problems arising out of water metering was directed to the possibility of using the Venturi principle for air. It was required that the whole air supply to the Rand Mines from the Victoria Falls Power Company should be measured. The credit for solving the problem and devising a meter which would correct for disturbing factors, such as temperature, pressure, humidity, &c., goes to the late J. L. Hodgson, who was for many years head of the firm's research department. Having thus broken away from the measurement of water only, the firm began to develop meters for the measurement of various other gases and liquids.

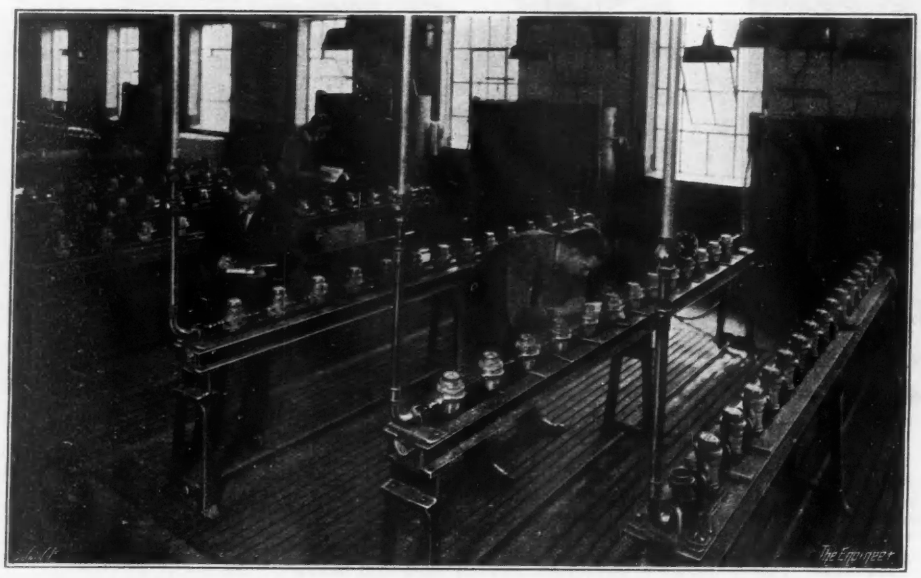
During the war the manufacture of pre-war productions was gradually dropped, until towards the end the whole efforts of the firm were directed towards the supplying of the national needs. In addition to the ordinary works at Luton, covering some 7 acres, another was established covering 28 acres of ground. In these two factories a dozen different types of fuse were constructed and filled with explosive. At the peak period the output was over 130,000 fuses per week.

Fortunately, the foresight of the directors was maintained under wartime conditions, and it was always remembered that difficulties might lie ahead when peace was restored. War profits were not divided among the shareholders, and thus a capital sum was available and was expended in recapturing markets lost during the war. At the same time the range of meters produced was much increased and the methods of manufacture altered. Before the war each product was more or less individually manufactured and put together. Now, however, nearly all the products are made on the mass system by the use of special tools and by the aid of scientific instruments and appliances, which were not previously available. Within the last six years a new department has been created with a product entirely different in nature, but which requires equally accurate fitting and construction. A special building houses a plant for the manufacture of the Bishop steering gear, now used on many motor cars, which has a capacity of over 4000 gears a week, and even at that is said to be scarcely capable of meeting requirements.

On page 708 and herewith we reproduce photographs in parts of the modern works.



AIR METER CALIBRATION SHOP



TESTING MECHANICAL WATER METERS

SIXTY YEARS AGO.

IN this paragraph in our issue of May 13th, 1938, we summarised an article, which appeared in our issue of May 17th, 1878, describing the experiments of Professor D. E. Hughes on the microphone. It was clearly implied in the article that Hughes was the inventor of the carbon and other forms of microphone, and that in the course of his work he had incidentally invented a thermometer of extreme sensitivity. Hughes is still regarded, in this country at least, as the inventor of the microphone. It is therefore with something of a shock that we find a letter in our issue of June 28th, 1878, signed jointly by Hughes and W. E. Preece—then chief electrician to the Post Office—in which they sought to refute certain claims which had been made in America by Edison that he had forestalled Preece in all his discoveries and inventions. A further shock awaits us in a leading article in the same issue in which—with a freedom characteristic of the times—we called upon Hughes and Preece to explain themselves and clearly intimated that on the facts as then before us we were more than inclined to accept Edison's claims. There was more in the dispute than the usual quarrel as to priority between rival inventors. Edison not only claimed to have invented the microphone before Hughes; he accused Preece of an act of bad faith in that he (Edison) had kept Preece fully informed of his work on the microphone, and thermopile, that he had personally demonstrated to Preece the principle of their action, and that Preece had in his possession in this country an Edison microphone at the very time when Hughes was describing his invention to the Royal Society. Edison even asserted that he had appointed Preece as his agent for the presentation of his inventions in England. Yet Preece, according to Edison, preserved complete silence when Hughes advanced his claims, and actually championed him as the discoverer of the microphone. In the joint letter from Preece and Hughes to which we have referred, they asked us to give the "most absolute and unqualified denial" to the "wild statements" that Edison had made. It was asserted by them that Hughes' microphone was quite different from Edison's, that Preece had given no information to Hughes, and knew nothing of his invention until it was shown to him by Huxley and Norman Lockyer, that they were in no sense co-adjutors, and, finally—in spite of our own description of the Hughes "thermopile"—that Hughes had never "brought out" such an instrument. As regarded Hughes, there was, we said, no evidence that he knew anything about Edison's work, although it was difficult to understand how one American electrician should be totally ignorant of the work of another American electrician, particularly one so well known as Edison. We felt, however, that Preece's case was different, and that an explanation from him was demanded.

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

UNDERFLOOR DUCTS FOR ELECTRICAL SERVICES.

No. 774—1938. With the increase in electrical facilities required in buildings, means have been developed to distribute these services to the positions at which they are needed, and of various methods employed for this purpose the most comprehensive are the under-floor duct systems. Under-floor ducts have been developed along two lines: —(*a*) Steel construction rectangular in section, and (*b*) a semi-circular fibrous material. This new specification for "Under-floor Steel Ducts for Electrical Services, with Fittings," covers the steel type now being brought into use. The Institution is preparing, and will shortly issue, a similar specification for fibrous ducts. A one, two, or three-duct system is provided for. One duct for use where it is intended to use only low-voltage services, such as bells, telephones, and signalling equipment; two-duct, one for the above services and the other for high-voltage services, such as lighting and power; and three ducts for use where it is desired to separate the telephones from the signalling equipment. The ducts are intended to be laid on the surface of the structural floor and covered by a layer of screed with draw-boxes at various points, flush with the finished floor surface. The depth of screed necessary for this purpose is about 3in.

THE SWAT RIVER CANAL.—Owing to a printer's error, the name of this river in our article in last week's issue was incorrectly spelt "Swab River."

GLASGOW EXHIBITION.—In connection with the fountain equipment at the Glasgow Exhibition, described in last week's issue, we are informed by Drysdale and Co., Ltd., of Yoker, Glasgow, that they supplied all the pumps, pipe work, nozzles, control valves, &c., the special automatic robot gear, and the new nozzle by which the white-water effect is attained. The General Electric Company, Ltd., was responsible for the lighting effects at the Royal Fountain and North Cascade. In reference to the work carried out by A. & J. Main, Ltd., mentioned on page 673, we are informed that the firm was responsible for the erection of the Concert Hall, but not of the two Scottish pavilions, the steelwork for which was fabricated and erected by P. and W. MacLellan, Ltd., of Glasgow.

Marine Engineering Problems of To-day.*

By STERRY B. FREEMAN.

THERE have been many papers read recently on the present-day development of marine engineering and on the possible future which lies before our industry. In most of these papers there has been an air of congratulation that we have travelled so fast and so far, and a general atmosphere of optimism as regards our future progress. It might therefore be timely to suggest that while we admit that we engineers are wonderful people, and that the children of our brains are wonderful also, still there remains quite a number of points where we must confess to a certain degree of frustration, if not failure, and in order to add to the pleasure of this meeting I propose to dwell for a short time on some of these questions, and to invite you to produce some solutions to the problems involved. It is probable that some weak spots have been left unmentioned, and your assistance is invited in adding these to the list.

There is, of course, a theoretical limit of efficiency which can never be quite attained in practice, which Nature has imposed for every type of prime mover. It is not suggested that any complaint is levelled against Nature. What is emphasised is that research and experiment in fundamental matters should be carried on continuously as experience has shown that in this way we make progress in practical technical details which may at first seem to have no connection with fundamental research. While admitting these limitations, engineers should not be satisfied with an ideal efficiency for a steam engine of, say, less than 35 per cent., or for an oil engine of, say, less than 39 per cent. In the efforts made to raise the standard of performance there has been a general elaboration of design and construction in all classes of marine machinery, which is contrary to the old order of things when simplication was the aim and economy of first cost was a very serious matter. The amount of money which must be spent to achieve the lowest possible consumption of fuel may be a good investment, but there is always a danger that more may be spent in first cost than is saved in subsequent economy. The modern high-pressure, high-temperature steam turbine and boiler and the later oil engines are equally under suspicion in this matter. It should be emphasised that the eternal search for efficiency is always right and to the good—it is the cost of achieving it that is the important qualification.

The present output of power per unit weight from various types of marine machinery is very different and of approximately the following order, on a basis of weight per S.H.P.:—

	Lb.
(1) Low-pressure steam and reciprocating engines with Scotch boilers	500
(2) High-pressure steam and geared turbines with W.T. boilers...	250
(3) High-pressure steam and electric transmission with W.T. boilers...	230
(4) Oil engines, direct drive, S.A. 2 S.C. or 4 S.C., supercharged	400
(5) Oil engines, direct drive, 2 S.C.S.A. or D.A....	350
(6) Oil engines and electric or mechanical gearing and clutch transmission of power	300

It is suggested that in all these systems, except the second and third, there is a long way to go before we should be satisfied with the power/weight ratio.

Steam Reciprocating Engines.—These are now supplied with high-pressure superheated steam and perhaps preheated L.P. steam; weight is reduced by the adoption of higher speeds, steel columns and single collar thrusts, and the power is increased by exhaust steam turbines interposed between the L.P. cylinder and the condensers, which drive on the propelling shaft mechanically or electrically, or the power is used to heat and dry the steam between the stages of the main engine. All these refinements have been adopted to reduce weight and running costs at the expense of first cost.

Are these systems too complicated for outputs below 1000 S.H.P., and would a turbine alone for powers above 6000 B.H.P. be preferable?

For these steam reciprocating engines pressures within the compass of the Scotch boiler are usual, and if high superheat is adopted there is a danger of passing lubricating oil from the cylinders to the condensers and ultimately to the boilers. Is there any effective way of filtering an emulsion of oil and feed water in such a case? All sorts of towelling, fibre and coke, or charcoal devices have been tried, and also an electrical plant, but in the space which can be given in a normal engine-room it is hard to get rid of oil from an emulsion. And how about the cost of such plant?

Turbines.—The characteristics of the turbine have given us a propelling plant of low contour, free from troublesome vibration, occupying small floor space, and of comparatively high efficiency and low steam consumption. Unfortunately, for its best performance high-temperature high-pressure steam is a necessity. The metallurgist has not yet given us the metals that will unfailingly resist these temperatures and pressures.

When the turbine was first introduced many of us thought that as there was no contact between rotor and stator there would be, apart from some small wear in the bearings, no repairs and no maintenance charges to face. Probably the bearing wear has been the least troublesome item in the turbine. It was not anticipated that casings would distort, crack, and erode, that shafts would bend, discs become loose, axial and radial packings leak, that blades would break, erode, and pit, and that binding wire would fail. But all these have occurred.

To prevent these happenings there has been a flood of ingenious invention, and the materials and the processes they go through have been much improved at greatly enhanced cost.

In spite of all precautions, however, there are cases where the engineer is baffled, as when, for example, a certain row of blades will fail repeatedly although renewed in modified and improved material. The erosion of turbine casings at the later stages can, by alteration of the pressure in the stages, be transferred from one stage to another as the mischief goes on, but no means of completely preventing this damage has yet been discovered. Another common failure is that of the later stages of L.P. blading, where probably the blades strike water, for which condition we have as yet no remedy. From experience of turbines which have had various rows of blades removed it seems that turbine design has not reached finality.

It is desired to go on towards pressures of 1500 lb. per square inch and temperatures of 450 deg. Cent. In view of the troubles we have at lower pressures and temperatures, is it safe to do so? And if we do, then it seems certain that some practicable scheme of reheating the steam between stages must be adopted, but how is this to be done in the limited space of a ship's engine-room? Will the method employed originally by Ferranti of transferring heat from highly superheated steam between the boiler and the first stage of the engine, to steam exhausted from a further stage in the plant, be applicable?

Condenser.—No satisfactory method has yet been devised to conserve the heat which is imparted to the circulating water by the steam which has been condensed. The method adopted in the mercury boiler system achieves this object to some degree, but not in a way which would be practicable in marine work.

In the same way the technique of gear cutting has been studied, and those tests, checks, and methods of calibration with which you are familiar have been evolved, so that now the gear-cutting machine in its glass case is performing miracles of accuracy, also at a commensurate cost.

It is regrettable that so far no means of running test bed trials of large steam plant are available to ascertain with certainty the relative economy of, for example, mechanical and electrical transmission of power. They are needed.

Electric transmission of power has been adopted in a number of important steamships where there have been some special reasons for its employment, such as to avoid the risk of broken teeth in mechanical gearing, to lessen vibration, and to reduce noise. It would be interesting to know if the above qualities are noticeably exhibited in comparison with other ships where the electric system is not used. It is generally understood that the consumption of fuel oil in those of our large ships which are fitted with turbo-electric propelling machinery is from 0·72 lb. to 0·78 lb. per S.H.P. hour in comparison with a consumption of 0·57 lb. to 0·6 lb. per S.H.P. hour in geared turbine plant. Our friends in the electrical industry will agree that these figures call for improvement. As regards the oil-electric system, the rate of fuel consumption will be on the same lines, and the oil engine at 250 r.p.m. is not so suitable as a fast-running turbine for the generation of electrical power. Means are needed to bring the losses of electrical gearing more closely into line with mechanical gearing with a corresponding reduction in fuel consumption per B.H.P. hour, and to reduce the weight and space required for electrical gear. Although electric, mechanical, and hydraulic gearing of all kinds have been successful, they must be paid for in capital cost, maintenance, and repair. Are we better without them?

It should be noted that the measurements of mechanical performance lag behind those of electrical performance, and an accurate and reliable meter is another long-felt want.

Oil Engines.—We have been promised the advent of a gas turbine, but it has not yet appeared. The advantage of a rotary type of oil engine seems probable. What is the difficulty which has arrested this development?

Like everything else in this world, there are always compensations. The old four-stroke cycle single-acting engine, with its cooling stroke between each power stroke, was very comfortable, but had a very high weight/power ratio. The two-stroke single-acting engine had a better weight/power ratio, and was going into the lead until the two-stroke double-acting engine arrived. Double-acting engines having a piston-rod through their lower combustion chamber must have a lower cover and stuffing-boxes. It may be urged that the top and bottom covers are weak spots in these engines, and that the opposed-piston engine avoids the danger by having no cover at all. The stresses in this engine are concentrated in the crankshaft. Is it better to have a cylinder cover fail from time to time, or an occasional crankshaft? The desirable answer is "Neither," but if there are to be no failures many of us will be out of our present employment, which is unlikely.

At any meeting of engineers dealing with oil engines it will be found that liner and piston ring wear cannot be kept long out of the discussion.

In the four-stroke single-acting engine the liner is a simple proposition, the pearlitic cast iron of which will last for, say, 50,000 hours. Some two-stroke and some double-acting engines have liners of comparatively complicated construction, and the cast iron for such is now alloyed with, for example, nickel, chromium, molybdenum, or vanadium and titanium, and even so these liners do not seem to give general satisfaction. What hope is there under these circumstances of increasing the life of the two-stroke cycle double-acting engine to compare with that of the four-stroke cycle single-acting engine, and further of using successfully so-called "boiler oil" in our engines, which is one of the objectives which should be kept in view? Is the remedy going to be the adoption of harder liners or the electro-plating of liners, or must the shipowner continue to pay for the lighter oils? And should the piston ring be softer or harder than the liner, or of the same metal and characteristics? Although much has been written about the wear of cylinder liners and piston rings in the internal combustion engine, no solution has yet been reached which finds general acceptance. Probably the correct solution of the problem is to make these of the same material, and as hard as possible so long as the hardness is due to the closeness of the texture of the material, and to make sure of effective lubrication of the upper part of the cylinder liner. As already said, the simple liner of the old 4 S.C.S.A. engine is not expensive, and lasts 50,000 hours, say, ten years; the liner for the modern 2 S.C.S.A. or D.A. engine costs about six times as much and lasts less than half the time. We cannot sit down contentedly with that state of affairs.

It is also suggested that the question of piston rings, whether for steam or oil engine pistons, is not finally decided. If a ring is used which is unrestricted in its expansion on to the cylinder wall, the pressure of the working fluid will get behind the ring and may increase the wear of both ring and liner. If, on the other hand, a ring of the restricted type is used in a cylinder which is not absolutely true in bore from end to end of the stroke, it obviously would either be held off the liner wall at points or would not actually be restricted in its operation.

The transmission of heat is, of course, bound up with the size of the cylinder and the amount of oil necessary to be burned to develop the power required. When pressure charging in the four-stroke cycle single-acting engine was adopted it was found that the additional heat released in the cylinder by the burning of additional fuel was removed by the additional air supplied for scavenging and for subsequent compression and combustion. Something of the same practice is wanted in the double-acting engine so that higher pressures and output can be achieved without incurring higher heat stresses.

As regards the running of modern machinery, one of the effects of forced lubrication is to conceal overheating and wear by carrying off the surplus heat unnoticed, and a simple and cheap means of warning the operator of such overheating is wanted.

A ship's structure is not rigid, chocks wear into the tank top, riveting slackens, and nothing but constant vigilance keeps bearings in line. That there is still much work to be done on the problem of shaft alignment is evidenced by the fact that at the time of writing these notes there are some six ships in the Tyne with broken crankshafts and fractured bed-plates.

The oil engine is tied to a fairly narrow range of oil for efficient running and maintenance, and every effort should be made by designers and users to discover how the heavier grades of oil can be used. The larger the oil engine the greater its heat problems and other difficulties, and the metallurgist and the engineer have to determine how far sizes and outputs can go.

Considering that Dr. Diesel originally designed his engine to burn coal, it seems that the advent of an efficient and trouble-free coal dust engine is overdue. This might help our coasting vessels to obtain cheap power. The question of obtaining a licence to manufacture a successful engine is perhaps a more difficult one than it should be if the industry is to advance by co-operation. If one firm has a monopoly of the manufacture of a successful engine, then all other firms are tempted to decry that firm's engine, which does not help co-operation.

Some years ago—in 1926—the author's firm issued a specification for the construction of a marine oil engine which should combine all the then known desirable features of a pressure-charged four-stroke cycle single-acting engine. Four such engines were built by two firms in collaboration and have been running now for eight years with practically no major renewals or repairs. The engine fitted in M.V. "Polyphemus" was tested by the Marine Oil Engine Trials Committee and showed a high efficiency. That sort of co-operation and standardisation appears to be useful and might be extended.

Boilers.—Present-day boilers are equally or more developed than the turbines which they supply. At one time a boiler was a kettle in which water was boiled. Now it has become a machine for the rapid production of steam. For many years the older types of water-tube boilers for use in the mercantile marine were rated so lightly that there was no particular advantage, from the weight and space point of view, in adopting these in lieu of the Scotch boiler. The difficulty of keeping up the brickwork of water-tube boilers, of firing coal by hand in their large grates, of keeping condenser tubes tight, and the inadequate quality of workmanship and material in them made the Scotch boiler preferable. With the competition of modern boilers, such as the Johnson in this country and the Wagner, Loeffler, La Mont, and Velox types abroad, the rating and output of these standard water-tube boilers have been greatly increased. This, however, results in the boiler, and in particular the steam reservoir capacity, being reduced in proportion to the output obtained. Are the best results to be obtained by natural, guided, or forced circulation?

To deal with our oldest friend, the tank or Scotch boiler. This has latterly come back into the picture, thanks to the improvements in steam engines, but an old problem still remains, why a boiler of this type should be built with such high factors of safety that its weight is a severe penalty on its use. It may be that the advance in the quality of workmanship and of steel has not been given its full weight. It is safe to say that these boilers would suffer less from the inevitable movement which goes on, due to expansion and contraction, if the shell and furnace plate thickness and also the stay diameters were reduced. Consider, for example, the boiler shell. This is formed by bending the plate beyond the elastic limit, and it is not subsequently annealed. It is obvious that the thinner the plate the less the internal stresses set up in the plate. The allowance of an additional thickness for wastage is unecessary, as the plate thickness is 15 per cent. more than is required, the strength of the seam being only 85 per cent. of the strength of the full plate. As regards stays, no water space stay fails through excessive corrosion at the centre of the stay. Stays almost invariably fail at the plating where the movement of the combustion chamber in relation to the shell plating or to another chamber has been more severe, and very little nicking is enough to cause failure.

The defect of many boilers of this type is that they tend to prime with the consequent damage to piston rings, piston-rod packing, turbine glands, nozzles, and blades, &c. The production of really dry steam is a matter of first-class importance, and although little is positively known of the cause and prevention of foaming and priming in marine boilers, it is believed that the reservoir capacity and the height of the steam outlet orifices above the water level and the purity of the water are all important. The latter is probably the biggest factor in the case. In the Admiralty type of water-tube boiler with its guided circulation priming is no longer a worry.

Fuel.—Much study and experimental work has been done on the burning of fuel oil in boilers, and progressively better results have been obtained in consequence. On the other hand, coal burning has not advanced in the same way. What has been done in marine work since Howden arranged valve control of air into boiler furnaces under forced draught?

From the shipowner's point of view the questions of

* International Conference of Naval Architects and Marine Engineers, London, June 16th.

reliability, cost, space, and weight are of importance in the order named. Whatever machinery is used must be taken in conjunction with the bunkers necessary for its performance, and in this connection for an equivalent weight coal occupies about 17 per cent. more space than oil, and the transport of the same number of heat units in coal entails moving about 50 per cent. more weight than in oil. Cannot these figures be improved upon? Coal might always be washed and then properly freed from water and graded. It should be burnt in pulverised form, but no scheme has yet been evolved whereby coal can be cheaply and effectively powdered in the stokehold or powdered in bulk ashore and safely carried in ships' bunkers without risk of coal dust explosion when at sea. What is wanted, perhaps, is some combination of duct keel, serving, by means of a suction hose, bunkers arranged in the cellular double bottom, so that it may be possible to send a ship to sea with powdered coal stored in the double bottom. Mechanical grates work well, but when a suitable coal is found for use with these the price of that coal promptly tends to go up. Mechanical means of bunkering ships are wanted which will not break the coal up into smalls and dust.

Mechanised firing is constantly under consideration for marine boilers, but this question is bound up with the considerations of first cost, of the supply of fuel at the right price, and of bunker space and weight. If the very low-grade coal which can be used with mechanical grates, or with powdered fuel plant, be selected, how much more bunker space will be needed to store the requisite number of heat units required? It is a transport as well as an engineering question, and the answer will differ with the service.

The present position of coal for bunkers has become in this country involved with political considerations to an extent that makes it impossible to deal with it on the lines of straightforward engineering economics, and a return is wanted to a basis competitive with other coal-producing countries.

At a recent meeting of the Institution of Naval Architects this question of the choice of fuel, coal or oil, was debated. On technical grounds it was demonstrated that oil gave a ship such range of action, speed, and other strategic advantages that coal could not successfully compete with it. All these arguments apply to the international commercial rivalry that is unceasingly going on, and no shipowner can avoid the necessity of equipping himself with the best ships with which to carry on the struggle if he is to survive. On political grounds it was urged that because Britain has no indigenous oil we should burn coal lest we could not obtain it from oil-producing countries. None of the speakers mentioned the fact that Germany, Italy, Japan, France, Spain, and the Scandinavian nations have no oil either!

What is most obviously needed is an economical process whereby our coal could be converted into liquid fuel, so that a ship might bunker the valuable heat units without the residues which add weight and bulk to the ship's fuel supply.

For vessels burning oil in oil engines a centrifugal oil cleaning plant, fully large enough to pass all the fuel intended for the day's use through it in, say, six hours' time, is an invaluable asset. A static type would do as well perhaps if it would take out water. Can such be devised?

There is a rumour that "boiler" oil is to displace "Diesel" oil. Perhaps these are differences in names and prices only. Given a clean oil of approximately the same viscosity, specific gravity, percentages of hard asphalt and sulphur as the "Diesel" oil in common use, and it can be burnt in an oil engine even if it is labelled "boiler" oil.

While many people are very indignant with the marine engineer who uses oil instead of coal, they quietly ignore the fact that even in the sheltered home market, where international competition is not so acute as in shipping, many of our engine builders are making a comfortable living out of the manufacture of oil engines. They ought, of course, to be building gas engines. They used to do so, but the cost of coal, even at their doors, is prohibitive, and the taxed foreign oil, being cheaper, has driven gas engines off the market. Some means is wanted of putting gas engines on smaller ships in the home waters of those countries which produce no oil, these ships bunkering gas instead of coal. The experiment of using gas engines was tried in the "Holzapfel" on the Tyne in 1910 (?), but it should be re-examined.

Another path of progress which needs clearing is that of invention. In the past century, the Industrial Revolution and our consequent comforts were the outcome and reward of the inventive genius that gave us the power of steam in our factories and for transport, the enormous addition to our resources which electrical power and light confer, and latterly the transmission of power to great distances. But to-day the inventor's way is usually a hard one. He has to pay for the monopoly which the patent confers upon him and further fees to keep up the protection of his idea. As a matter of practice very few busy people will trouble to sit down to invent something specifically to meet the difficulty they may be in, because they realise that, from the financial point of view, the inventor is very largely wasting his time. The exception to this generalisation is that of an invention protected by the firm who can manufacture it, which is not in the same category.

Inventions are an addition to the riches of the country in which they are made and should be encouraged as much as practicable by the State.

Standardisation is another matter where we have not yet in many cases arrived at clear decisions.

Most engine works standardise their units—bolts, nuts, certain fittings, and so on—as one might standardise bricks but not a house. For steam installations of, say, 4000 S.H.P. and upwards, turbines are usually employed; below that power reciprocating engines with or without an exhaust turbine. The question arises, can steam practice be standardised in the same way in view of the great divergence of pressures, temperatures, and types and lay-out of boilers and machinery involved? With the advent of the oil engine, standard sizes of cylinder pistons and piston-rods, &c., have become possible, and a complete engine can be built up for varying powers out of standard units on mass production lines. But the ideal that there would be one standard type of oil engine, in the same way that there was for years a standard type of steam reciprocating engine, is as far or farther off than ever.

As standardisation will tend to lessen the capital cost of the manufacturer's plant, shorten the time of delivery of machinery, and reduce the amount of spare gear necessary to be carried, it is obviously a desirable end if it can be compassed and more of it is wanted.

It is only fair to add that the firm that standardises an engine is in danger of being overtaken and passed by a competitor with a new engine, and that the shipowner may find his ships obsolete if he carries standardisation too far. How far can standardisation of parts be carried to assist manufacture and use without checking progress?

Looking backwards, it appears that the advance which has been made since the inventions of the steam engine, the steam turbine, and the oil engine has been bound up very closely with the advance in workmanship, including, of course, accurate machining, and with metallurgy, and it is probably on the future progress of metallurgy that the rate of development will depend. We are still in need of cheap, standardised material capable of withstanding high pressures and temperatures, and resistant to such evils as creep, brittleness, and corrosion. That there is much to be learnt is evident. Physicians do not know the cause and cure of the common cold. In the same way metallurgists cannot tell us why common wrought iron resists the ravages of time so much better than steel.

Cast iron has travelled on through pearlitic cast iron to be alloyed with chromium, copper, vanadium, titanium, molybdenum, and nickel. Are we on the eve of something definitely so superior to our past practice that we can standardise it?

Steel has been similarly alloyed and has been tempered, quenched, and/or annealed in all these forms. Will there be a simplification of these processes, *e.g.*, can tempering be omitted for gear pinions? In the eyes of marine engineers brass, in the form of condenser tube, is one of the outstanding triumphs of metallurgy since the discovery of aluminium brass, 76 C, 22 Zn, 2 Al. What is now wanted is the similar discovery and development of a metal to stand up to the temperature of burning oil, say, a modest 1500 deg. Cent. (It sounds more reasonable in Centigrade!) And an oil that will lubricate at that temperature. And nuts and bolts that will not be at or above their annealing point under these conditions.

Further research is needed into the use and relative value of protective coatings, to guard our low-pressure turbine casings from corrosion and our oil engine cylinder liners from wear.

More light is needed on the question of the propeller and the conditions under which it works; for example, in determination of the actual pitch of the propeller, taking into account the aerofoil sections of the blades, the effect of appendages, and particularly the bossing. On comparing the results of model naked hull trials, it is obvious that no such differences exist in the hulls alone as are exhibited between these hulls when fitted with those bossings which are considered to be the most suitable for their purpose. Are the bossings now fitted almost as a matter of course in multiple-screw ships really necessary and advantageous? Should we not do as well or better with bare shafts and A brackets as in much naval practice? Can bare shafts be adequately protected from corrosion? Is it certain that to fit propellers amidships, as suggested by John de Meo, is not practicable and of advantage?

Someone has pointed out that if we are ever inclined to think that we have arrived and there is no more to be done, it is a good thing to make out a brief balance sheet, putting on one side the things we know and on the other side the things we don't know. It should have an invigorating effect. This paper is intended in some small way to fill such a want, and is presented to you in the earnest hope that it may be welcome.

American Engineering News.

Welded Hospital Building.

A six-storey building, designed for three additional stories later, forming an extension of the New York Hospital at Brooklyn, is the first large all-welded steel-frame building in New York City. The specifications permitted either riveted or welded construction, at the contractor's option. In simple beam-and-column designs welding is usually more expensive, unless the connection details are carefully worked out in advance, and in this case such details were prepared and delivered to contractors who proposed to submit tenders. The lowest tender was based on welding. The noiselessness of this method of erection was an advantage, since the hospital contained hundreds of mental patients, but the adoption of the method was based on cost alone. At some other hospitals welding has been insisted upon for the preservation of silence. Except for the connections, there was little difference in the framing, but in some of the lower stories the beams were somewhat lighter, since their end connections were not weakened by rivet holes. For welded connections, the stresses used were 18,000 lb. for compression, 13,000 lb. for tension, and 11,300 lb. for shear. Over 600 tons of steel were included in this building, about 60 tons less than for riveted construction. Shop welding comprised 3240 lineal feet of fillet welds and 400ft. of butt welds, with a total volume of 2440 cubic inches or 4 cubic inches per ton. Field welding included both fillet and butt welds, having a total length of 3150 lineal feet, with a theoretical volume per ton slightly less than that for shop welding. The total welding time was about 800 man-hours. This building is about 350ft. long and 40ft. wide, with framing consisting mainly of beams connected to columns, except for trimmer and header beams at floor openings. Floor construction consists of reinforced concrete joists and hollow terra-cotta blocks. The heavy wind bracing connections required for riveted work, with frames designed to resist wind pressure without assistance from walls and partitions, accounts for the large saving in steel tonnage, nearly 10 per cent.

United States Public Water Policy.

The recent report of the Water Resources Committee—which is composed almost entirely of members connected with the U.S. Government administration—takes the view that water conservation projects should be based on a broad plan covering all the various uses and dangers of water. Also, that the plan should be considered on the basis of individual drainage basins or watersheds, regardless of political divisions. The control of water in this way must be considered as a problem for public welfare rather than as a purely engineering problem. Under the Flood Control Act of 1936, a definite policy for participation by the Federal Government in the construction of flood-protection projects was established. As to the Ohio-Mississippi River problem, there is still no plan for protection against floods of maximum height. Long study is needed as a basis of such a plan, so that there is no economic warrant for starting a programme of construction works. It is considered that detention reservoirs in the tributary streams have little value in protecting the main valley from major floods, though they have real value in the conservation of water and in reducing the frequency and height of minor floods. On the other hand, study should be made as to the possibilities of large reservoirs near the mouth of the Ohio and mouths of large tributaries of the Ohio and Mississippi rivers. As to inland waterways the Committee points out that demands for transportation are not increasing, and that many projects have not sufficient traffic to justify the great expenditures that have been made. Of particular importance is the Committee's suggestion of Government toll charges for the use of improved waterways. Plans for river regulation should include possibilities of power development, since power consumption has already taxed the existing power production facilities. Irrigation is needed for some 700 million acres, but most of the smaller projects have already been carried. Drainage of swamp lands is considered to be a local problem, and pollution of streams is a serious matter that relates largely to certain areas or districts.

California Irrigation Project.

Intensive irrigation is the present feature of the great central valley of California, the earlier wheat-growing area being now developed into more profitable orchards and vineyards, and the vast cattle ranches now largely changed to alfalfa and cotton fields. This valley comprises about one-third the area of the State, or some 55,000 square miles, and two-thirds of the agricultural area, with a semi-tropical climate and a population of about a million, all dependent on an adequate water supply. But drought is a menace, wells are going dry, and already thousands of acres of growing land have been abandoned and are reverting to desert conditions. To check this retrogression and provide an increased and permanent water supply for irrigation is the purpose of the Central Valley reclamation project, which will cost some £35,000,000, with works already under contract amounting to £1,200,000. It will conserve much of the present seasonal waste of water by the construction of dams for storage reservoirs on the San Joaquin and Sacramento rivers, and the distribution of water by a system of canals. The Government will be repaid eventually by the sale of water and of power developed at the dams. The works will include the Shasta dam, of concrete, 560ft. high and 3100ft. long, with ten discharge outlets, two of which will be equipped with balanced needle valves for regulation of flow, and five penstocks will serve a hydro-electric plant of 350,000 kW capacity, feeding a transmission line 200 miles long. Its waste weir or spillway will be controlled by drum gates and the reservoir will have a capacity of 4½ million acre-feet. The Friant Dam, also of concrete, will be 286ft. high and 3300ft. long, with a reservoir of 450,000 acre-feet serving three main concrete-lined canals, 160, 50, and 45 miles long, the largest having a bottom width of 30ft. and carrying water 15ft. deep. In all there will be 350 miles of main canals, and a series of pumping stations and canals for irrigating areas of high lands. About 40 miles of railway and 40 miles of highway within the future reservoir areas will have to be reconstructed above this future water level.

Bridge Erection by Floating.

In the construction of a long highway bridge over an arm of the sea at New York, fourteen spans were erected on barges and floated into place on the piers. One span, being partly over the land, was erected on falsework. The main span is a 540ft. through-truss lift span, raised between steel towers. At each end is a through-truss span 540ft. long, and the other spans are deck trusses from 97ft. to 214ft. long. The bridge has a four-lane roadway, 44ft. wide, and a 6ft. footpath. Concrete paving is used on the deck spans, and for the entire length of the footwalk, but on the three through-truss spans and the towers the roadway is of open-steel grating. The weight of steel is about 13,000 tons, including 3500 tons of silicon steel for the long trusses and the towers. In construction, the lower portion of each tower was first floated into place on the piers, and a derrick was erected on one tower, at the level of the roadway. Two steel barges, 325ft. long, lashed side by side, but 15ft. apart, were moored at this tower and carried steel falsework on which the lift span was erected, material being brought by barges. Derricks at each end of the span were then placed for erection of the towers. A similar method was used for the two adjacent spans. For the deck spans however, erection was done at a convenient place along the shore five miles distant, the barges and spans being then floated out to the piers with the aid of tugs. These barges were 186ft. long and 34ft. wide, lashed together in pairs by steel cables. The tidal range is about 5ft., and the barges were towed into place at high tide and held by anchor cables attached to pneumatic winches. As the tide fell the span was seated on the piers and released from the falsework. Each of the long spans weighed 1800 tons complete, while the car floats and falsework made a total floating load of nearly 5000 tons. The deck spans weighed from 150 to 400 tons. The lift span, equipped for operation, weighs 2180 tons, and is raised and lowered by cables on drums operated by four 200 H.P. motors on the tops of the towers.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Our Steel Trade with Iraq.

The report on Economic and Commercial Conditions in Iraq, 1935–37, issued by the Department of Overseas Trade (price 1s. net), follows the report upon the adjoining country of Iran reviewed in these columns last week. It is pointed out that improved world prices for agricultural products during 1936–37 resulted in a considerable expansion in both the export and import trade of the country. A far-reaching decision was made late in 1936, when the Government decided to proceed with the completion of the railway system by linking the existing railways with the Turco-Syrian railhead at Tel-Kotchek, *viâ* Mosul. When this line is completed it will undoubtedly play a useful part in the development of the northern areas of the country. Imports from the United Kingdom have increased steadily for the past three years, and for last year are considerably in excess of the previous highest total recorded in 1929–30. The value of the shipments of iron and steel from the United Kingdom rose steeply in 1936–37, whilst, on the other hand, imports from Germany declined in the latter year. The volume of imports from Belgium, however, rose to an exceptionally high figure. Although in 1937 the British trade in some sections fell off slightly, notably in pipes and joists, large orders for rails, which were placed by the Iraqi Railways, considerably increased the British shipments. The report points out that the demand for rails, rolling stock, and other railway equipment is likely to continue until the programme of railway expansion is completed. Other manufactures of iron and steel which were imported in considerable quantities from the United Kingdom in 1937 were buildings or parts of buildings, castings, metal containers in barrels, switches, chains and cables, nails, steel furniture, and tools. Imports from Germany included bars, locks, and nails, whilst, in addition to being the main supplier of joists, Belgium provided a large share of Iraq's requirements of bars, sheet iron, and hoops. Great Britain appears to have secured in the face of keen competition from other countries a valuable share of the market for boilers, machinery and mechanical apparatus. The value of imports of electrical machinery and equipment has grown considerably during the past few years.

The Pig Iron Market.

It is obvious that the stocks of pig iron which have accumulated are passing very slowly into consumption, and naturally with so much iron available, consumers are displaying no inclination to enter into fresh commitments. They can obtain sufficient for their needs without delay, and, in fact, most of them have to receive larger quantities against contracts entered into some time ago than would serve their immediate requirements. In the foundry iron department the process of assimilation seems to be particularly slow, largely because the light castings industry is for the most part working at a low rate of output. An improvement in the demand for these products is dependent to a great extent upon an expansion in the building trade, and this seems unlikely for some time to come. The heavy engineering trades, however, are taking fair quantities of foundry iron and for the time being are the best customers. On the North-East Coast there is little demand either upon home or export account, and it is estimated that most consumers in the present state of trade have covered their needs for two or three months. The export trade is particularly bad and the price asked of £5 10s. f.o.b. for Cleveland No. 3 quality is too high to attract foreign consumers who can buy French and Belgian iron at from 62s. 6d. to 67s. In the Midlands the slackness in the demand has become very noticeable since the beginning of June, and the general view is that it will be at least three months before the situation becomes normal and the stocks of iron in the producers' and consumers' yards have been reduced sufficiently to encourage the latter to enter the market. The stabilisation of prices until the end of the year is not encouraging fresh buying, and in many cases contracts which are worked off are not renewed. The principal demand comes from the industries which are affected by the rearmament programme, and these include the motor car, machine tool, and aeroplane makers. These are the users of low phosphoric iron for which their requirements have created a fair demand. The fact that prices of this description of iron are not controlled permits of wide variations, and figures ranging from £5 10s. to £7 d/d have been heard of. Whilst large stocks of hematite exist in this country, there has been some improvement lately in the weights called for by users. The demand, however, is not sufficient to make much impression upon the stocks, and unless there is a further curtailment of production, it is difficult to see how additions to these accumulations can be avoided.

Current Business.

The London and North-Eastern Railway has placed a contract with the Birmingham Railway Carriage and Wagon Company, Ltd., for thirty non-vestibuled carriages, consisting of fifteen twin sets. A similar contract has been placed with the Metropolitan-Cammell Carriage and Wagon Company, Ltd., for forty-two carriages of twenty-one sets. A large battery of coke ovens having a weekly output of 3500 tons of coke is being constructed by the Stanton Ironworks Company, Ltd., at their works near Nottingham. The section of the works of W. P. Butterfield, Ltd., tank makers, Shipley, producing dustbins has been transferred to new premises acquired at Low Well, Shipley. The new premises were formerly a textile engineering works, which the company has adapted to its requirements. The Development Committee of Leeds City Council has received inquiries from two American manufacturers for details of industrial sites. Work will be commenced shortly upon the sinking of a new coal mine at Branchal, Lanarkshire, by the Coltness Iron Company, Ltd., which will be driven under Cambusnethan and into the Greenhead area. Plans have been concluded between Darwins, Ltd., Sheffield, the Superior Steel Company, of Pittsburgh, and the Ludlum Steel Company, of Watervliet, for the manufacture of stainless steel. An agreement has been reached by which the Sheffield firm will work to the American companies' patents and technical processes. The new Calder Bridge which is being built by Dorman, Long and Co., Ltd., Middlesbrough, for the London and North-Eastern Railway on the Doncaster-Leeds line over the river between Sandal and Wakefield will be completed during June. The Department of Overseas Trade announces that the following contracts are open for tender:—Durban, General Stores Department: eight electrically driven carcase dressing hoists (Durban, July 1st); South African Public Works Department: air-cooled condenser type refrigerating unit and water cooling unit (South Africa, July 7th); New Zealand, Timaru Harbour Board: ten dredger buckets with cast steel backs (Timaru Harbour Board, July 21st).

Iron and Steel Imports.

The following figures, taken from the Board of Trade Returns for May, disclose that imports of iron and steel and manufactures thereof again dropped in tonnage, although the value is above that for April. The May imports totalled 55,665 tons, valued at £789,566, against 61,469 tons, valued at £708,213 in the previous month. Only the figures for the most important countries are given:—

	1937. Total. Tons.	1938. April. Tons.	1938. May. Tons.
Pig iron: Total	644,687	35,197	19,890
British India	214,985	25,574	13,334
Foreign countries	394,729	9,623	6,556
Ferro-alloys	77,994	3,188	4,826
Blooms, billets, and slabs:			
Total	434,163	3,691	11,618
British countries	82,670	5	7,310
Sweden	2,253	32	2
Germany	43,055	—	—
Belgium	95,270	826	115
France	140,836	2,828	4,087
Other foreign countries	70,079	—	104
Sheet bars	98,608	—	—
Wire rods	96,771	3,115	2,263
Other bars and rods	196,398	2,003	1,681
Angles, shapes, and sections	72,695	1,281	1,310
Girders, beams, joists, &c.:			
Total	70,664	1,637	1,178
Belgium	14,342	10	26
France	35,660	1,255	958
Other foreign countries	20,662	372	194
Plates and sheets (not coated)	49,742	908	2,395
Wrought tubes	36,386	1,813	2,104
Railway material	8,087	571	552
Bolts, nuts, and metal screws	8,672	618	725
Total from countries:			
British India	215,215	25,574	13,334
Canada	163,738	3,492	9,848
Germany	133,572	3,139	3,056
Sweden	105,136	7,420	8,434
Holland	27,881	625	480
Belgium	528,121	5,535	4,007
Luxemburg	134,076	642	564
France	316,540	8,068	7,244
Czechoslovakia	16,718	1,053	1,060
United States	315,412	3,120	2,855
Total imports, iron and steel	2,039,463	61,469	55,665

Iron and Steel Exports.

The exports of iron and steel and manufactures thereof, according to the Board of Trade Returns, showed a further decline to 167,522 tons, valued at £3,647,453, in May, compared with the totals for April of 168,318 tons, valued at £3,709,008. The following are details of the exports:—

	1937. Total. Tons.	1938. April. Tons.	1938. May. Tons.
Pig iron: Total	153,540	5,516	5,346
Forge and foundry	87,016	3,533	3,675
Acid	65,951	1,983	1,671
Basic	573	—	—
Ferro-alloys	13,642	149	260
Sheet bars, bright steel bars, and wire rods	32,011	1,642	2,225
Bars and rods, other kinds	123,618	10,242	10,533
Angles, shapes, and sections	76,454	6,822	7,363
Girders, beams, joists, &c.	34,408	2,427	5,002
Hoop and strip	57,902	4,346	2,552
Plates and sheets, ¼in. and over: Total	195,350	11,895	13,637
South Africa	13,097	843	886
British India	13,156	1,361	1,454
Australia	5,456	624	720
Canada	11,767	153	351
Other British countries	30,984	2,944	2,776
Denmark	32,235	3,413	5,749
Holland	32,685	1,074	320
Plates and sheets under ¼in.:			
Total	157,314	5,573	6,635
British India	6,328	418	317
Australia	15,943	2,673	3,579
Canada	17,512	95	180
Mexico	10,530	498	—
Argentine Republic	68,710	895	755
Galvanised sheets	224,489	12,477	16,049
Tinned plates	438,054	28,712	25,993
Tubes, pipes and fittings: Cast:			
Up to 6in. diameter	60,800	3,142	3,428
Over 6in. diameter	47,821	2,288	2,219
Wrought	267,862	17,869	17,135
Railway material:			
Steel rails, new	155,896	14,823	10,957
Sleepers, fish-plates, and sole plates	32,156	3,559	1,200
Total all iron and steel	2,576,033	168,318	167,522

Copper and Tin.

The announcement that the world's production of copper would be curtailed to bring it more into line with the demand did not take the market by surprise. The situation had become complicated not only by the poor consumption in the United States, but by the action of the producers in that country in increasing their exports to Europe. The market outside the United States was therefore to some extent threatened by the American producers, and as for some time the world's copper trade with the exception of America had been on a satisfactory scale, it was apparently decided by the producers of the rest of the world that a general cut in production would be better than the possible deterioration of European and other markets by larger American exports. It must also be remembered that the market had been largely supported by sales to Japan and Russia, and as these countries are no longer buying so heavily, it is probable that the course adopted is the wiser one. Opinions differ as to the effect on tonnage of the cuts from 105 to 95 per cent., but it is generally put at between 6000 and 7000 tons per month. This may not be a heavy reduction, but it has been sufficient to create a more optimistic feeling in the market and a firmer tendency in prices. It is interesting to note that the American figures for May give the production as 149,340 tons compared with 162,580 tons in April. The American production was 47,300 tons compared with 55,749 tons in the previous month, whilst the world's stocks on May 31st were 554,350 tons against 541,750 tons at the end of April. The latter figures include the American stocks which totalled 369,800 tons at the end of May and 355,363 tons on April 30th. Prices on the London standard market strengthened on the news of the cut in the American production and a rather better tone developed. . . . Tin prices advanced sharply in anticipation of the establishment of the Buffer Pool. The expected statement which followed the meeting on June 20th confirmed the impression that the quota for the Pool had been fixed at 10 per cent. of the standard tonnage and the quota for the market at 35 per cent. The announcement stated that the scheme as finally agreed was signed, and would be published as soon as possible. According to the figures available, the production for the market will be about 100,000 tons per annum, and the amount of metal going into the Pool about 20,000 tons. It is understood that the Pool will buy tin when the price falls below £200 and will sell when it rises above £230 per ton. The question which is agitating the market is whether when the scheme is in full operation the supplies will not be reduced to a level below the current consumption. On the other hand, of late there has been a tendency for the demand from the world's consuming industries to decline somewhat, and it is possible that this process may become more noticeable since the summer is the quiet period of the year. At the end of last week consumers bought rather heavily and Continental buyers also showed more interest in the market.

Lead and Spelter.

The lead market shared in the improvement in sentiment which made itself felt in the early part of this week, and prices have steadily advanced. The whole of this movement was not maintained, but it resulted in a change for the better in the position. The most noticeable feature of the situation is the scarcity of prompt metal, which is largely due to the absence of shipments from Mexico. The tightness in the prompt position became noticeable in the latter part of last month, and since no arrivals are expected until the middle of July, it is possible that the stringency will become accentuated. Most of the arrivals of Empire lead appear to be in satisfaction of existing contracts, so that no real relief can be expected from this direction. Consumers have shown an inclination recently to depart from the policy of buying from hand to mouth, which they have maintained for some weeks, and to take a longer view of the market. In this respect, however, the improvement is only relative, and it would seem that most of the consuming industries are fairly well covered for the time being. The cable makers continue to be the largest consuming industry in this country, but good quantities of metal are also being taken up by the manufacturers of lead pipes and sheets. In fact, the manner in which the output in the latter department is maintained is highly satisfactory. Other consumers are receiving fair tonnages against existing contracts, although until the beginning of this week they showed a disposition to hold aloof from the market so far as new business was concerned. On the Continent the demand remains good, whilst in America business has expanded recently. This is considered to be a good sign, since the persistent depression in the market on the other side of the Atlantic has influenced sentiment in Europe. . . . Prices in the spelter market have shown an advancing tendency this week, but the fundamental conditions have not materially altered. Consumption is on no more than a moderate scale, but, on the other hand, the supplies are in excess of market requirements. Whilst this position rules it is not likely that consumers will alter their policy of limiting their purchases to hand-to-mouth quantities. The recent cuts in output have not yet had time to affect the supplies, and the impression prevails that stocks are still increasing. Most of the consuming industries are finding a somewhat poor outlet for their products, and this naturally reacts upon sentiment. The Continental market remains dull, but at times there have been some spasmodic bursts of buying which have given it a more cheerful appearance. The low price at which the metal stood, however, and the activity in other departments of the non-ferrous metal markets encouraged speculative operations. To a great extent the rise in values is due to this movement. So far as consumption is concerned any improvement appears to have been largely confined to the demand for high grade spelter. Business in ordinary grades has been on a limited scale.

Current Prices for Metals and Fuels.

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from associated British Steelmakers. †Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-.

	Home.	Export.
	(D/d Teesside Area.)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	6 12 6	—
,, No. 1	6 13 0	7 7 6
Cleveland—		
No. 1	5 11 6	6 2 6
No. 3 G.M.B.	5 9 0	6 0 0
No. 4 Foundry	5 10 0	5 19 0
Basic	5 0 0	—
MIDLANDS—		
Staffs—	*(Delivered to Black Country Station.)*	
North Staffs. Foundry	5 11 0	—
,, ,, Forge	5 6 0	—
Basic	5 0 0 to £5 5 0	—
Northampton—		
Foundry No. 3	5 8 6	—
Forge	5 5 6	—
Derbyshire—		
No. 3 Foundry	5 11 0	—
Forge	5 8 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	6 13 0	—
No. 1 Foundry, ditto	6 0 6	—
No. 3 Foundry, ditto	5 18 0	—
Basic, d/d	5 7 6	—
N.W. COAST— Hematite Mixed Nos.	6 13 0 d/d Glasgow 6 18 6 ,, Sheffield 7 4 6 ,, Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS AND YORKS—	£ s. d.	£ s. d.
Crown Bars	13 5 0	—
Best Bars	13 15 0	—
MIDLANDS—		
Crown Bars	13 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	11 12 6	—
No. 4 Quality	12 2 6	—
SCOTLAND—		
Crown Bars	13 5 0	13 5 0
Best	13 15 0	13 15 0
N.E. COAST—		
Crown Bars	13 5 0	13 5 0
Best Bars	13 15 0	13 15 0
Double Best Bars	14 5 0	14 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	13 17 6	—

STEEL.

	*Home.	†Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	11 3 0	10 12 6
Tees	12 3 0	11 12 6
Joists	11 3 0	10 12 6
Channels	11 8 0	10 17 6
Rounds, 3in. and up	12 3 0	11 12 6
,, under 3in.	12 15 6‡	11 0 0
Flats, under 5in.	12 15 6‡	11 0 0
Plates, ⅜in. (basis)	11 13 0	11 0 0
,, ½in.	11 18 0	11 5 0
,, ⅝in.	12 3 0	11 10 0
,, ¾in.	12 8 0	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ⅜in.	12 3 0	12 2 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 10 0
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
,, under 3in.	12 13 0‡	11 0 0
Plates, ⅜in. (basis)	11 8 0	11 0 0
,, ½in.	11 13 0	11 5 0
,, ⅝in.	11 18 0	11 10 0
,, ¾in.	12 3 0	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ⅜in.	11 18 0	12 2 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
,, under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ⅜in. (basis)	11 10 6	11 0 0
,, ½in.	11 15 6	11 5 0
,, ⅝in.	12 0 6	11 10 0
,, ¾in.	12 5 6	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ⅜in.	12 0 6	12 2 6

STEEL (*continued*).

	*Home.	†Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	11 0 6	11 12 6
,, under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ⅜in. (basis)	11 8 0	11 0 0
,, ½in.	11 13 0	11 5 0
,, ⅝in.	11 18 0	11 10 0
,, ¾in.	12 3 0	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G.)	12 10 0	12 10 0
Boiler Plates, ⅜in.	11 18 0	12 2 6
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	11 0 6	10 12 6
Tees	12 0 6	11 12 6
Joists	11 0 6	10 12 6
Channels	11 5 6	10 17 6
Rounds, 3in. and up	12 0 6	11 12 6
,, under 3in.	12 13 0‡	11 0 0
Flats, 5in. and under	12 13 0‡	11 0 0
Plates, ⅜in. (basis)	11 10 6	11 0 0
,, ½in.	11 15 6	11 5 6
,, ⅝in.	12 0 6	11 10 0
,, ¾in.	12 5 6	11 15 0
Un. ⅜in. to and incl. 6 lb. per sq. ft. (8-G)	12 10 0	12 2 6

IRELAND—F.O.Q.—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	11 5 6	11 8 0
Tees	12 5 6	12 8 0
Joists	11 5 6	11 15 6
Channels	11 10 6	11 13 0
Rounds, 3in. and up	12 5 6	12 8 0
,, under 3in.	12 18 0‡	13 0 6
Plates, ⅜in. (basis)	11 13 0	11 15 6
⅝in.	11 18 0	12 0 6
¾in.	12 3 0	12 5 6
⅞in.	12 10 0	12 10 0
Un. ⅜in. to ½in. incl.	12 3 0	12 5 6

‡ *Rounds and Flats tested quality; untested 9/- less.*

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. f.o.b. £ s. d.
11-G. and 12-G., d/d	14 15 0	11-G. to 14-G 12 10 0
13-G., d/d	15 2 6	
14-G. to 20-G., d/d	15 10 0	15-G. to 20-G 12 15 0
21-G. to 24-G., d/d	15 15 0	21-G. to 24-G 13 0 0
25-G. and 26-G., d/d	16 10 0	25 and 26-G. 13 15 0

South Africa, Rhodesia, Nyasaland £14; Canada £14 12s. 6d. f.o.b. basis. Irish Free State, £15 15s., f.o.q., four-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10 cwt., £2 per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.—

Home.	£ s. d.
4-ton lots and up	18 10 0
2-ton to 4-ton lots	18 17 6
Under 2 tons	20 2 6

Export; India, £18 15s. c.i.f.; Irish Free State, £18 10s. f.o.q.; General, £16 15s. f.o.b., 24-G. basis.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 20/3 to 21/6.

Tin-plate Bars, d/d Welsh Works, £7 15s.

Billets. 100-ton lots and over, 35 to 100 tons, 5/- extra: less than 35 tons, 10/- extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 17 6
,, ,, ,, tested	8 7 6
Basic (0·33% to 0·41% C.)	8 12 6
,, Medium (0·42 to 0·60% C.)	9 2 6
,, Hard (0·61% to 0·85% C.)	9 12 6
,, ,, (0·88% to 0·99% C.)	10 2 6
,, ,, (over 0·99% C.)	10 12 6
Rails. Heavy, 500-ton lots, f.o.t.	10 2 6
,, Light, f.o.t.	9 2 6

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro Tungsten	4/8 per lb. (nominal)	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 5 0	7/6
,, ,, 6 p.c. to 8 p.c.	£24 0 0	7/6
,, ,, 8 p.c. to 10 p.c.	£24 0 0	7/6
,, ,, Max. 2 p.c. carbon	£36 0 0	11/-
,, ,, ,, 1 p.c. carbon	£38 5 0	11/-
,, ,, ,, 0·50 p.c. carbon	£41 0 0	12/-
,, ,, ,, carbon-free	1/- per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£18 15 0 home	
,, Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- p.u.	
,, ,, 75 p.c.	£17 0 0 scale 6/- p.u.	
,, Vanadium	14/- per lb.	
,, Molybdenum	4/9 per lb.; 5/- forward	
,, Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton.	
Cobalt	8/6 to 9/6 per lb.	

NON-FERROUS METALS.

(Official Prices, June 22nd.)

COPPER—		
Cash	£36 3 9 to £39 6 3	
Three Months	£36 8 9 to £36 10 0	
Electrolytic	£40 15 0 to £41 0 0	
Best Selected Ingots, d/d Birmingham	£40 15 0	
Sheets, Hot Rolled	£70 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	11¾d.	11¼d.
,, Brazed (basis)	12d.	12d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£34 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	10¾d.	10¼d.
,, Brazed	12¾d.	12¼d.
TIN—		
Cash	£187 5 0 to £187 15 0	
Three Months	£188 5 0 to £188 10 0	
SPELTER—		
Cash	£13 8 9 to £13 10 0	
Three Months	£13 13 9 to £13 15 0	
LEAD—		
Cash	£14 16 3 to £14 18 9	
Three Months	£14 15 0 to £14 16 3	
Aluminium Ingots (British)	£100 to £105	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—	
Navigation Unscreened	18/6 to 19/-
Hamilton Ell	17/6
Splints	19/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	15/6 to 15/9
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	17/- to 17/6
Unscreened Navigation	18/- to 18/6
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	16/6 to 17/-
Secondary Steam	16/-

ENGLAND.

SOUTH YORKSHIRE, HULL—	
B.S.Y. Hards	21/6 to 22/-
Steam Screened	19/- to 19/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	18/3 to 18/6
,, Seconds	18/-
,, Best Small	17/-
Unscreened	18/- to 18/3
DURHAM—	
Best Gas	20/6
Foundry Coke	28/- to 32/6

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	24/- to 24/6
Best Seconds	23/6 to 24/-
Best Dry Large	23/6 to 24/-
Ordinaries	23/6 to 24/-
Bunker Smalls	17/6 to 19/-
Cargo Smalls	16/6 to 17/6
Dry Nuts	24/6 to 25/6
Foundry Coke	37/6 to 55/-
Furnace Coke	28/- to 30/-
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	38/- to 41/-
Machine-made Cobbles	41/- to 51/-
Nuts	40/- to 50/-
Beans	33/- to 38/6
Peas	26/- to 30/-
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	20/- to 25/-

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon
Furnace Oil (0·950 gravity)	3½d
Diesel Oil	4½d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Production and Working Hours.

STATISTICS are published every month of the production of different industries, and an index figure is obtained for each branch of industry and for industry as a whole, so that a fair means of comparison is available for ascertaining the fluctuations of national industrial activity. As bases of comparison, an index of 100 is taken for 1913, and for the peak year of 1928, but the former date can offer no precise conclusion, in view of the fact that the country's production capacity has been greatly increased by the industrial development that took place after the war. The latest figures published for the month of April are not sufficiently complete to allow all the different industries to be compared individually with the figures for 1928, but the total shows that, compared with 1913, the index figure is 93, which is the lowest production yet reached, except in August last year, when works and factories closed down for the annual holidays and the index fell to 91. In the case of individual industries, of which the production is known, the index for the iron and steel trades, compared with the peak year of 1928, is 69. The figure for the engineering industries is not yet available. For motor cars it is 67 and the building trades 59. Only in the paper trade is the index figure for 1928 largely exceeded. It is difficult to say how much of this declining production is due to economic causes other than the short working week, which are, in fact, closely interrelated, but there can be no doubt that the fewer individual working hours are solely responsible for the fall in the coal output, since the colliery industry is protected by import quotas and the supply is far below the demand. The working week is 36½ hours at the face, and notwithstanding an increase of several thousands in the number of hands employed, the output has failed to reach its former level. The index figure rose from 89 in January last to 95 in April as the result of the miner's union temporarily authorising additional hours in order to meet a national emergency. All reports and statistics confirm the failure of the forty hours' system, and Monsieur Jouhoux, the general secretary of the C.G.T., who has returned from Geneva, where the forty hours have again been shelved for another year, confesses that French labour is too seriously handicapped by the refusal of other countries to follow its lead, and now that 2000 hours a year have been legalised with additional hours to meet emergencies, there is every indication that working hours will be allowed to adapt themselves to industrial necessities.

North Atlantic Air Service.

Air France Transatlantique is likely to be in the running next month with Imperial Airways, Pan American Airways, and Deutsche Lufthansa for the establishment of air services across the North Atlantic. France had concentrated so much on her supremacy in the South Atlantic that she neglected her chances of pioneer work in the North Atlantic, though continuing her efforts to secure suitable intermediate refuelling stations. Air France had the good fortune to sign in 1933 a contract with the Portuguese Government for the exclusive right to use the Azores, but the contract lapsed through failure to pay the annual indemnity, and since then the French company has had no alternative but to concentrate its efforts on flights between the Etang de Biscarosse, in the Landes, and the United States, with a possible intermediate landing in the Bermudas. The only suitable machine at present is the reconditioned "Lieutenant-de-vaisseau-Paris," and another giant seaplane of similar type is expected to be completed shortly. These machines, however, are intended for experimental flights. In order to avoid the hazards of a non-stop flight, Air France Transatlantique has obtained from the Portuguese Government permission to use the Azores for seven voyages between Lisbon and New York, the first of which will probably take place at the end of July. Deutsche Lufthansa has secured a permit for fourteen flights during the period of July to October. While the "Lieutenant-de-vaisseau-Paris" is making tests along the southern route, it is proposed to use the sister seaplane under construction for a northern route by way of Iceland and Newfoundland. Air France Transatlantique has, nevertheless, not abandoned the idea of a non-stop service between Biscarosse and New York in the summer and to Baltimore during the winter months. It is not certain that the Azores will be permanently available, for the Portuguese Government is said to aim at diverting the North Atlantic air traffic with the Continent by way of the Azores through Lisbon. The French company is not opposed to such an arrangement, and it constituted the basis of the contract that was allowed to lapse some years ago because there were no machines suitable for the more arduous flying conditions than those existing in the South Atlantic. If the Portuguese Government can be induced to come to terms with Air France Transatlantique, the Portuguese route may be adopted, but there are attractions in a direct French route that is not subjected to obligations, and three machines have been ordered for the purpose, two of them of exceptionally long range, which it is hoped to complete for service in 1940.

Shipbuilding.

In the annual report of the Chambre Syndicale of French Shipbuilders, the new shipbuilding programme raises the question of the yards making preparations to deal with the tonnage to be constructed if the plan is carried through and orders are spread over a number of years. When the slump in shipbuilding became acute, the Government compelled some of the smaller yards to close down, against the advice of the Chambre Syndicale, which refused to admit that there were too many slipways for building in normal times, and while a concentration and a certain specialisation of the industry have given good results, there is stated to be a deficiency of skilled labour through men being drawn into State arsenals and factories. Shipbuilders can arrange to meet all requirements on condition that the programme is put in hand as a whole and spread over a sufficiently long period, and that the present Government succeeds in its task of bringing about a better understanding between workers and employers.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

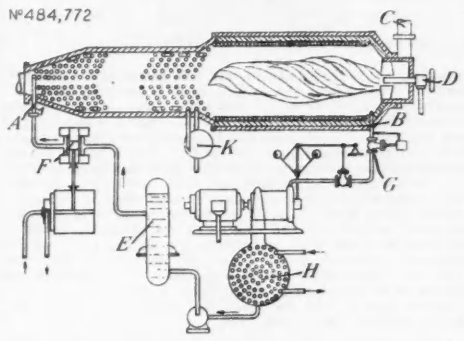
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton-buildings, Chancery-lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

484,772. September 7th, 1937.—INSTANTANEOUS WATER-TUBE BOILERS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

The heating surface of the instantaneous water-tube boiler is constituted by a tube system consisting of a continuous serpentine extending from the inlet end A to the outlet end B. The first part of the serpentine is arranged in the form of a number of conical layers of tubes which are heated by the smoke gases. The farther the water or steam flows through the serpentine towards the outlet end, the greater is the amount of heat supplied by the smoke gases. The second part of the serpentine is heated directly by the radiation of heat from the flame. At the outlet end the steam emerges from the serpentine in a superheated condition. The heating burner is constructed as an eddy burner to which combustion air is supplied tangentially at C and fuel centrally at D. Guide vanes are incorporated to augment the eddying. The feed water is taken from the reservoir E and supplied to the device F, which is driven by a motor and supplies the feed water to the serpentine

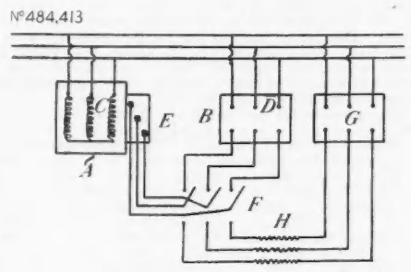


in a pulsating manner, so that during the feed strokes there are pulsations in the flow which are separated by periods of rest. F may, for example, be a piston pump which, on each stroke, introduces a pulse of water into the serpentine. In accordance with the pulsations in the flow there are similar variations in pressure which are propagated through the entire length of the serpentine. Arranged at the outlet end of the serpentine is a device G which, when the pressure increases, affords a large opening, and when the pressure drops affords a small opening. The oscillations arising from the pulsating feed are in this way balanced out at the end of the serpentine so that the steam flows uniformly. The steam from the boiler is utilised to drive a machine, and thereafter is condensed in the condenser H. A pump feeds the condensate back into the reservoir E, where the cycle commences afresh. Connected to the serpentine between F and G at that point in the serpentine where the foreign matter in the feed water separates from the residual water, is a chamber K which separates the residual water from the steam. The steam freed from the foreign matter flows into the superheater, whereas the residual water with the foreign matter is removed from the chamber K.—*May 10th*, 1938.

DYNAMOS AND MOTORS.

484,413. November 4th, 1936.—ELECTRIC MOTOR CONTROL, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2, and Bernard Adkins, of 13, Fisher-avenue, Rugby, Warwickshire.

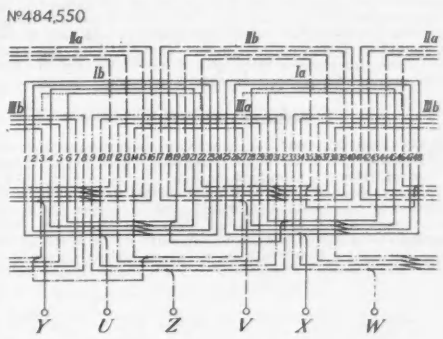
The shunt polyphase commutator motor with an induction regulator, a transformer, or an auxiliary stator winding connected to the commutator provides a convenient variable-speed drive for many applications, and the invention consists in providing a simple and rapid method of bringing a motor of this type to rest from any speed. The diagram shows typical connections for carrying out this method of braking. A is a shunt commutator motor and B a regulator used for controlling its



speed. The primary windings C and D of motor and regulator respectively are connected to the alternating-current supply and the commutator E of the motor and the secondary windings of the regulator are connected together through the change-over switch F. By changing over this switch the commutator of the motor can be connected to the secondary G of the transformer, the primary of which is connected to the alternating-current supply. In series with the secondary G of the transformer is an impedance H. Reactance may also be introduced in this circuit by building the transformer G so as to have a high reactance. Instead of making B a regulator and G a transformer, either or both may be an induction regulator, a transformer, or an auxiliary winding on the motor stator. If B is an induction regulator, G may consist of additional windings on the regulator. A single transformer and impedance H may be used for a number of motors.—*May 4th*, 1938.

484,550. September 11th, 1937.—WINDINGS FOR A.C. DYNAMO-ELECTRIC MACHINES, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

According to this invention, a winding for A.C. dynamo-electric machines is provided in which the winding ends of concentric coils are situated in three planes, the windings being chorded by interleaving adjacent sides of coils of different phases. A practical example of the winding is shown in the accompanying drawing, which illustrates a concentric winding for a bi-polar three-phase machine having forty-eight slots. The chording amounts to 19 : 24 = 0·795. The winding has three phases, each consisting of two parts, I_a—I_b, II_a—II_b, and III_a—III_b, wound in opposite directions. The first phase is shown in continuous lines, the second in broken lines, and the third in chain-dotted lines. Instead of the conductor 27 being allocated to the left-hand side of the phase half I_a, in addition to the con-

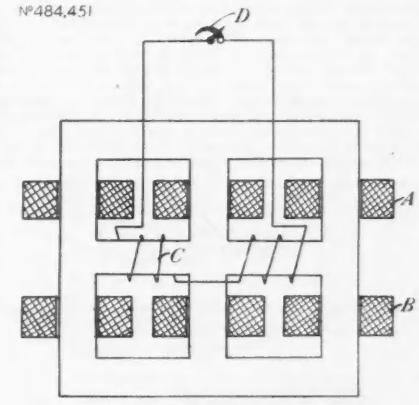


ductors 25, 26, and 28, and the conductor 46 being allocated to the right-hand side of the same phase half in addition to the conductors 48, 47, and 45, the conductor 30 is provided for the left-hand side and the conductor 43 for the right-hand side of the phase half I_a. Correspondingly, the conductors 19 and 6 are provided for the phase half I_b instead of the conductors 22 and 3. The conductors 27 and 46 of the phase half I_a are allocated to the phase parts III_a and II_a, while the conductors 22 and 3 are allocated to the phases II_b and III_b. The other phases are similarly arranged. As will be seen, adjacent sides of coils of different phases are thus interleaved and the phase halves are chorded.—*May 6th*, 1938.

TRANSFORMERS AND CONVERTERS.

484,451. September 30th, 1937.—ELECTRIC TRANSFORMERS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

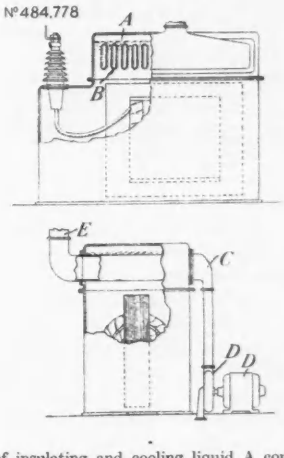
According to this invention, a three-phase welding transformer supplying a rectifier is constructed with magnetic shunts provided in the form of intermediate yokes fixed in the magnetic circuit between the primary and secondary windings. They carry a winding which forms part of a closed circuit connected across a regulating resistance. If the full resistance is inserted into the winding circuit of the intermediate yoke, the maximum leakage action is obtained. In proportion to the



amount by which the regulating resistance is reduced, the leakage action of the leakage yokes is diminished through the magnetic reaction of the windings on the leakage yokes. By fitting the wound intermediate yoke it is possible to regulate by purely electrical means the leakage action of the transformer, and thus to regulate welding current strengths in any desired range. The transformer core has three limbs on which the primary windings A and the secondary windings B are placed. The fixed intermediate yoke is fixed in the magnetic circuit between the primary and secondary windings and carries a winding C connected across a regulating resistance D.—*May 5th*, 1938.

484,778. September 27th, 1937.—COOLING MEANS FOR ELECTRIC TRANSFORMERS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

The transformer described in this specification is immersed



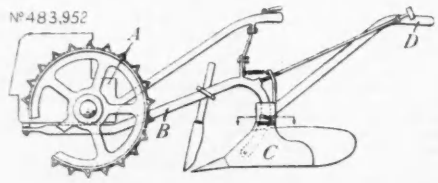
in a body of insulating and cooling liquid A contained in a metal casing. The space above the liquid, preferably filled with an inert gas, such as dry nitrogen, is provided to permit expan-

sion and contraction of the liquid. Metal tubes B are arranged horizontally in the upper part of the liquid, and each of these tubes extends through opposite side walls of the casing and thus communicates at each end with the outside air. The tubes are parallel to each other and spaced apart, and are preferably flattened with their greatest diameters arranged vertically. They are also preferably arranged so that their upper edges extend above the level of the liquid when the liquid is cold, but so that they are completely immersed in the liquid and below its level when the liquid is fully expanded and the transformer is carrying its maximum safe load. The ends of the tubes opening through one side of the transformer casing are covered by a manifold C which is connected to a blower or fan D operated by a motor. Cooling air may thus be forced through the tubes by the blower. An outlet manifold and pipe E may be provided if desired to conduct the air from the other end of the tubes where they open through the opposite wall of the casing.—*September 27th*, 1938.

MISCELLANEOUS.

483,952. July 6th, 1937.—MOTOR PLOUGHS FOR AGRICULTURAL PURPOSES, William Milne Catchpole, Cages Farm, Whepstead, Bury St. Edmunds, Suffolk.

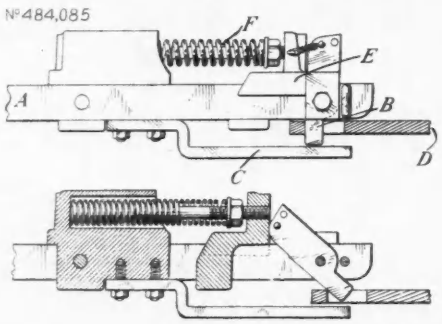
This specification deals with hand-steered motor ploughs for agricultural purposes. According to the invention, the hand-steered agricultural motor plough illustrated comprises a two-wheeled motor-driven tractor unit A and a single-share plough unit, including a share with its breast or breasts C, a plough frame and a beam. The beam B extends longitudinally and is



pivotally coupled at the forward end to the tractor unit in such a way as to have a freedom for swivelling movement relatively to the tractor unit as well as pivotal movement in a horizontal plane. The steering handles D extend from the plough unit and are adapted to be grasped by a man walking behind the plough. The interconnection between the two units is of such a form that by laying over the plough unit to one side or the other, or by bearing down to one side or the other on the steering handles, steering movement is imparted from the plough unit to the tractor unit.—*April 29th*, 1938.

484,085. October 27th, 1936.—COUPLINGS FOR VEHICLES, Frank Slatter, of Manor Farm, Kingham, in the County of Oxford.

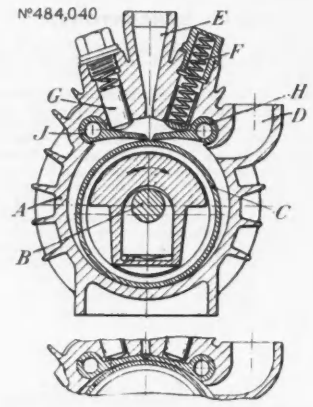
This specification covers mechanical couplings where two members are to be coupled together and are subject to tension or compression, and it is desired to provide a construction in which the coupling will automatically become unfastened upon a predetermined tension or compression being reached. In one construction, in which the coupling device is constructed to give an automatic release upon reaching a predetermined tension and in which the coupling is applied to the end of the draw-bar of an agricultural machine, this draw-bar A is formed at its rear end with a pair of cheeks which are parallel but spaced apart, and between these cheeks the trigger B is pivoted on a horizontal axis. Below the cheeks the draw-bar is provided with a plate extending parallel to the underside of the cheeks, but spaced away from it, and the lower end of the trigger projects down into this space. The trigger lever is acted upon by a light spring so that a ring or loop D on the end of the



draw-bar of the trailing machine may be pushed in between the underside of the cheeks and the upper side of the plate, displacing the lower arm of the trigger as it enters. The light spring acting on the trigger lever brings the lower arm of the trigger lever into engagement with the opening in the ring or loop when the latter has been pushed into position. The trigger lever is retained in its working position to take the tension arising from traction by a slide E mounted on the cheeks of the draw-bar acted upon by a strong compression spring F, pushing it towards the end of the tractor draw-bar, the motion being arrested by stops secured to the outer surfaces of the two cheek plates. The arrangement is such that when tension is applied to the lower part of the trigger the upper part has its forward edge forced into contact with the slide, and movement of the trigger lever is arrested. Upon abnormal tension taking place the force on the trigger lever is sufficient for the upper part of the trigger to force the slide which is mounted on the cheeks to move back until the lower part of the trigger lever moves out of engagement with the opening through the ring or loop of the draw-bar of the tractor, so that the coupling is thereby released. This position is shown in the lower view.—*April 27th*, 1938.

484,040. June 2nd, 1937.—CONTROLLING ROTARY COMPRESSORS, Alessandro Tebaldi, of 18, Via C. Ilarione Petitti, Milan, Italy.

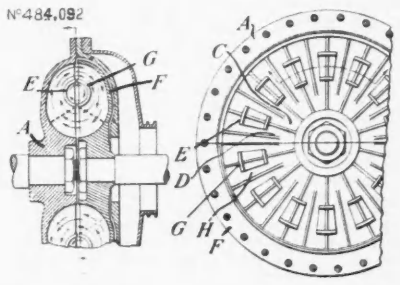
The invention relates to rotary compressors and its object is to provide an arrangement for controlling the fluid outlet in compressors of this type. The invention is characterised by the fact that for the separation between the compression chamber of the compressor and the delivery conduit there is a blade pivoted in the casing in such a position that when the blade is adjacent to the casing its free edge is in contact with the movable partition separating the suction conduit from the delivery conduit. In this way all dead space in the compressor is eliminated. A form of construction of the invention for the case of a compressor having a piston which rolls against the internal surface of the cylinder is shown diagrammatically in the accompanying



drawings. A is the casing in which is provided a cylindrical chamber coaxial with the driving shaft B carrying an eccentrically journalled drum C constituting the rotor or rotary piston of the compressor. The suction conduit is shown at D and the delivery conduit at E. The separation between these two conduits is effected by the blades H J. The inner faces of the blades have the same curvature as the cylindrical surface of the chamber of the casing, a portion of which they constitute when they occupy their final positions after compression of the spring-loaded tappets E and G. As soon as the pressure in the chamber becomes greater than the thrust on the blade the latter is detached from the drum and the fluid is able to pass into the chamber and into the delivery conduit. As shown in the lower view, the chamber is finally completely eliminated at the instant at which there is neither suction chamber nor compression chamber, and the compressor therefore operates without dead space.—*April 29th*, 1938.

484,092. October 28th, 1936.—IMPROVEMENTS IN HYDRAULIC COUPLINGS, *Harold Sinclair, of* 38, *De Vere Gardens, Kensington, London, W.*8.

The invention communicated relates to hydraulic couplings of the kinetic type, comprising an impeller member having radial or partly radial vanes coaxial with and juxtaposed to a runner member also having radial or partly radial vanes, these members together forming a toroidal working circuit for the coupling liquid. In the improved hydraulic coupling shown in the drawing the impeller A has thirty uniformly spaced radial vanes lying in planes containing the axis of rotation of the coupling. These vanes are alternately long and short, being denoted by C and D respectively. The impeller carries core guide means in the form of a ring which is completely interrupted at fifteen places. This ring is formed by fifteen core guide elements E, each of hollow semi-circular section and all of the same length, spaced at uniform intervals equal to the length of an element.



The elements project equally on each side of the vanes which carry them, and these vanes are continued across the interior of the elements. The ends of the elements lie in planes containing the coupling axis. The short vanes have a continuous straight edge running between the flow and the return junctions of the impeller and running members. The runner F has twenty-eight vanes and fourteen core guide elements G interrupted by spaces H, being otherwise constructed similarly to the impeller. The improved couplings have a slightly lower slip when completely filled than an ordinary Vulcan or a Vulcan-Sinclair coupling. They have no flat spot effect at loads which reveal such an effect with known couplings having core guide rings. Their characteristic curves of quantity to slip at constant impeller speed have a better general shape than the corresponding curve of the known couplings, especially when driving fans and like loads. Furthermore, they are easier to construct owing to simplification of the cores required in casting the vaned elements and are easier for removing core sand from the circuit passages.—*April 28th*, 1938.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INTERNATIONAL ENGINEERING CONGRESS.—At Glasgow.

TO-DAY AND TOMORROW.

BRITISH WATERWORKS ASSOC.—Twenty-seventh annual general meeting and conference at Plymouth.

MONDAY, JULY 4TH, TO FRIDAY, JULY 8TH.

INST. OF ELECTRICAL ENGINEERS.—Summer Meeting at South Midland Centre.

WEDNESDAY, JULY 13TH, TO FRIDAY, JULY 15TH.

INST. OF MINING ENGINEERS.—Summer meeting at Manchester.

THURSDAY, AUG. 25TH, TO FRIDAY, SEPT. 2ND.

WORLD POWER CONFERENCE.—Vienna sectional meeting.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MUREX WELDING PROCESSES, Ltd., advises us that it is moving to new offices and works at Hertford Road, Waltham Cross, Herts.

THE Right Hon. the Earl of Clarendon, K.G., P.C., G.C.M.G., and Mr. T. W. Heather, M.C., have joined the board of the General Electric Company, Ltd.

CROMPTON PARKINSON, Ltd., advises us that as a result of the increase in business conducted by its Manchester plant sales office, larger premises have been taken at Blackfriars House, Parsonage, Manchester, 3. The lamp and cable departments will continue to operate from Northern House, 7, Gartside Street, Manchester.

CATALOGUES.

HOLMAN BROS., Ltd., Camborne.—Catalogue of compressed air operated vee engines.

MORSE CHAIN COMPANY, Ltd., Letchworth, Herts.—Illustrated price list of standard chain drives.

J. PAYEN, Ltd., Church Street, W.4.—The 1938 illustrated price list of gaskets of all sizes and types.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C.2.—Abridged list of "Witton" A.C. and D.C. motors and motor starters.

SIEMENS SCHUCKERT (GREAT BRITAIN) Ltd., 30-34, New Bridge-street, E.C.4.—Particulars of Siemens and Halske disc meters for liquid fuels.

STURTEVANT ENGINEERING COMPANY, Ltd., 147, Queen Victoria-street, E.C.4.—Catalogue No. 1035, on propeller fans and small electric ventilating sets.

THOMAS SMITH AND SONS (RODLEY), Ltd., Rodley.—A folder illustrating and describing the Smith "Seven" eight cubic feet capacity universal excavator and its work.

PARSONS ENGINEERING COMPANY, Ltd., Town Quay Works, Southampton.—A folder illustrating a number of uses to which the firm's range of industrial engines are being put.

MARSHALL, SONS AND CO. (SUCCESSORS), Ltd., Gainsborough.—Particulars of a surface levelling attachment for application to the firm's multi-cylinder, oil-engined road rollers.

CROFTS (ENGINEERS), Ltd., Thornbury, Bradford.—Catalogue F.C.237, describing the ball-operated multiple-disc clutch, which has been designed for machine tool and machine work.

HOLOPHANE, Ltd., Elverton-street, Vincent-square, S.W.1.—A sixty-four-page booklet describing the firm's products and containing much data on scientific industrial illumination.

W. J. FRASER AND CO., Ltd., Dagenham, Essex.—Particulars of "Dowtherm," the high-temperature heating medium for which the company holds the sole selling rights in the British Empire.

DRAYTON REGULATOR AND INSTRUMENT COMPANY, Ltd., West Drayton, Middx.—A folder showing the construction, operation, and principal advantages of the Drayton-Armstrong steam trap.

TECHNICAL INFORMATION BUREAU OF LEAD INDUSTRIES DEVELOPMENT COUNCIL, 19, Hobart-place, S.W.1.—Publications dealing with the protection and maintenance of structural steel work.

BRITISH ALUMINIUM COMPANY, Ltd., Adelaide House, King William-street, E.C.4.—Data books for aluminium sheet work and machine bar stock, and brochures on aluminium jointing, annealing and heat treatment.

BURTON GRIFFITHS AND CO., Ltd., Montgomery-street, Sparkbrook, Birmingham.—A bulletin of the Erie Foundry Company, illustrating and describing its range of steam drop hammers for which Burton Griffiths and Co. are now sole agents in this country.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—Catalogue N 2, on paper dielectric and electrolytic condensers for radio, television, telephony, and neon signs; catalogue N.C.3.T., on magnetic moulding machines; catalogue N.C.2.M. on overhead equipment for tramway and trolleybus lines.

END OF VOL. CLXV.